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R. W. Kirkham.
Springfield.
Jan^y 14^th 1834

Works of Theology.

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A

CATECHISM

OF

NATURAL THEOLOGY.

"EVERY HOUSE IS BUILDED BY SOME MAN;
BUT HE THAT BUILT ALL THINGS IS GOD."

BY I. NICHOLS, D. D.
PASTOR OF THE FIRST CHURCH IN PORTLAND.

SECOND EDITION:
WITH ADDITIONS AND IMPROVEMENTS.

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CATECHISM

OF

NATURAL THEOLOGY.

INTRODUCTION.

Teacher. What do you understand by Natural Theology?

A. Theology, derived from two Greek words employed to signify our knowledge of God, is divided into two parts, natural and revealed. Revealed theology embraces those extraordinary discoveries which God has made to mankind in the holy scriptures. Natural theology teaches what may be known of God, from the manifestations of his existence and perfections in the natural world.

T. What do the scriptures observe respecting natural theology?

A. While the scriptures principally require us to know God, as he has revealed himself to us in his di-

vine word, they also require us to contemplate his being and providence, as they are manifested in the objects of nature. *Lift up your eyes on high, and behold who hath created these things.* They speak of the works of creation as presenting the plainest proofs of an all-powerful and divine Author. *The invisible things of him from the creation of the world are clearly seen, being understood by the things which are made, even his eternal power and Godhead.*— They invite our attention to the wonders of creation, as a most noble and delightful study. *The works of the Lord are great, sought out of all them who have pleasure therein.* They call upon the heavens and earth, the seas and mountains, the animal, the herb, and every thing which exists, to celebrate the praises of the Creator; that is, they require of *us* to study his providence ourselves, as exhibited in these various forms, and elevate our souls to him, in the contemplation of that almighty power and munificence, which are displayed in every part of the universe. It was a common practice with our Saviour, in teaching his disciples, to make use of the works of nature in leading them to reflect on heavenly and spiritual things. *Behold the fowls of the air. Consider the lillies of the field.*

T. What other reasons recommend this study?

A. While it is adapted to cultivate our devout feelings, and render the universe a perpetual temple for the worship of its infinite Author, the study of nature is most worthy of a rational curiosity. It is suited to every capacity. It may be enjoyed in every

situation. Its field is boundless; its novelty inexhaustible. If the eminence of an artist attach a higher interest to his productions; if we should crowd to see the works of a Phidias, a Praxiteles, or a Raphael, with what emotions should those objects be surveyed, which lead up our thoughts to an Almighty Author. Shall we reserve our curiosity for the imperfect exhibitions of our own limited powers, and be indifferent to the study which reveals in every form the hand of Infinite Wisdom? Whatever reason we can imagine for the study of human inventions, a far higher, surely, may be adduced for directing our attention to those Divine contrivances which immeasurably surpass them. There is scarcely an art but has its more simple and admirable parallel in some natural provision. Nature either furnishes the pattern, or exemplifies the result in a more perfect manner. The telescope was improved, and the first idea of it probably suggested, from an examination of the *Eye*. What is the most finished statue, compared with the living form? The works of art are soon exhausted; and by a critical inspection we can easily discover blemishes and imperfections in them. But the more closely we examine their great originals in the vast kingdom of nature, the more proofs do they afford us of the perfection of the works of God, in comparison with the highest efforts of human skill. Shall our interest then be excited at hearing of any new engine or piece of machinery which some one has invented? shall novelty be attractive and almost irresistible, when

there are these imperfect objects to call it forth ? and shall we be indifferent to the innumerable wonders of nature around us, the examination of which would prove a sure mean of enlightening our minds, exalting our thoughts, and advancing our piety ?

T. How do we arrive at the knowledge of an Almighty Creator, from contemplating the spectacle of the universe ?

A. The countless manifestations of design, and the continued display of bountiful provisions through all nature, are a proof of some designing power, and of a power beneficent and good, that is, of the Being whom we denominate God. If we should deem it absurd to suggest that a watch was an accidental combination of wheels and springs, not intended for any purpose, how much more irrational to suppose that so many manifestations of design, in the universe, exist without design ! When the humblest appearances of order, arrangement, and adaptation to use, in any object, even in a bird's nest, would lead us to pronounce it not a casual formation, but the production of some animal, shall the infinite spectacle of subserviency, proportion and harmony, which the universe presents, impress no conviction of design or of a designing cause ? Shall design cease to be deducible when once we have ascended from the mysterious operations of animal instinct and human reason ? We know there is designing intelligence in animals or men, only from what they perform. We call them intelligent, only because they act as if they were so. This is our only evidence. If they were destitute of interior faculties,

they would still preserve the same outward appearance. It is only, in any case, the existence of intelligent acts that proves the existence of an intelligent principle. And shall the work evince the workman in every instance but where the work is an exhibition of *infinite* contrivance? Must he be pronounced intelligent, who has written a book concerning the wonders of nature, and those wonders themselves not be equal to sustain a similar conclusion? What incredible blindness, to have suggested such a presumptuous absurdity!

T. If we should see the most superb palace in the world, or the most magnificent production of human art, should we not be delighted and amazed? Why then, are we not daily and hourly filled with rapturous emotions, in contemplating that infinitely nobler spectacle which is continually open to our inspection?

A. "The miracles of nature are exposed to our eye, (as a celebrated French writer beautifully expresses it), long before we have reason enough to derive any light from them. If we entered the world, with the same *reason* which a spectator carries with him to an *opera*, the first time he enters a theatre,—and if the curtain of the universe, if we may so term it, were to be rapidly drawn up, struck with the grandeur of every thing which we saw, and all the obvious contrivances exhibited, we should not be capable of refusing our homage to the Eternal Power, which had prepared for us such a spectacle." But we do not think of marvelling at objects we have seen for

so many years, or we think of them less, because they have so often been before us.

T. Is this an argument in favor of those studies which are adapted to awaken an attention to the works of God?

A. It is. We ought, if possible, to be always *extending* our acquaintance with the wonders with which we are surrounded, which proclaim an all-wise and beneficent Creator, so that we may *pause and suspend our thoughts*, and feel more sensibly the demonstrations of Providence, by observing them continually displayed in some *new* form.

T. It is for this reason, in part, we shall particularly examine the human structure, which has not probably been much attended to by most of you. But I intended to ask you, whether it is requisite to the evidence of design, that we should at once perceive the architect himself?

A. By no means. I do not require to see the maker of a machine, to be convinced that a maker was originally employed in the construction. If I should find a palace in a desolate wild—with not a human being to be seen, this would not lead me to suppose that it never had an architect. It does not, therefore weaken the demonstration of a creative Intelligence, that the Architect of the universe is unseen. In truth, when I come to reflect, I am sensible I never beheld *any* architect, in reality,—not even a human one. The outward form, which is all I ever perceived is not the architect. The real architect is the thinking, contriving mind; and this was never seen

by any human being. I could not, therefore, expect to behold the Author of the universe, when I never beheld the author of any other production.

T. This was the thought of *Socrates.* Does it lessen the proof of an Infinite Intelligence, that we do not understand every part of the universe, and that many events are mysterious?

A. Far from it. There are many productions of human skill, which the inventors only can explain. The wisest conduct of the parent often appears mysterious to the child. We cannot wonder, therefore, if the ways of Infinite Wisdom are frequently inscrutable.

T. Can you mention any religious advantage, which *young persons* particularly may be expected to derive from this study?

A. Every religious impression is most important in early life. Our admiration of outward objects should be directed into a devout channel at that period, when they strike our senses the most powerfully. Happy, if we are not then deficient in any knowledge which may enable us to perceive in every thing around us, the proofs of divine wisdom and beneficence, and lead us to view the beauties of nature with perpetual reference to their Author.

T. Has this study any recommendation as a useful *exercise* to the mind?

A. The study of uses and designs in nature, must conduce to a habit of careful observation and just reasoning,—and thereby promote one of the most important objects of education, in that way in which the

young would be most likely to be interested in the pursuit.

T. For this purpose, which seems the more useful, *general* contemplation of what is beautiful and sublime in the works of nature, or examining carefully into *particular* instances of design?

A. To gain clear and distinct impressions, it is necessary to inspect single examples minutely, and to fix our attention upon the details of divine wisdom and goodness.

T. What example most directly invites our notice?

A. That example we have in *ourselves*, seems most immediately our concern. Every part of the universe may be equally curious, but none can be so interesting to us, as our own frame. Whatever we may know of the wisdom displayed in our own structure, how frequent are the occasions which remind us of it! We cannot but feel the most sensibly that care which is manifested for our own benefit. Not a child could be indifferent to an instance of divine goodness, immediately concerning himself. We need not be anatomists, but we certainly ought to possess some general knowledge of those exhibitions of Almighty power and skill which have the most intimate claims upon our regard.

T. What you are to describe, is only a general outline of our wonderful machine. The object is not to teach you a system of anatomy, but merely to notice some of the leading marks of design in the human frame, so fearfully and wonderfully made. I

hope they may lead you to a more realizing sense of the Being around us, and dispose you to study with more attention that still higher revelation of himself, with which he has privileged us in his holy word. Though we shall speak only of *particular* instances of design, it is not because there are not innumerable others equally deserving our notice; the object merely being, to select a sufficient variety of examples that may be easily understood, and to present them in some order which may assist your recollection. You may begin with what has been called the noblest part of the human structure.

THE HEAD.

A. The head holds the first rank of all the visible parts of the body.

T. Principally, because it contains the brain.—You are aware how important the brain is, and that the least injury may occasion the loss of the senses, and be followed by fatal consequences. What do you remember upon this subject?

A. The brain is considered as the seat of sensation, to which the impressions of all the nerves are transmitted; the more immediate residence of the living principle; and the organ with which Providence has mysteriously connected the exhibition of

sensitive and intellectual powers. How it is the instrument of such important uses, we are wholly unable to explain. No anatomical examination has led to the least discovery. It is sufficient that, while it is the most important organ of the animal system, we see a corresponding care in several natural provisions, to protect it from injury, and to preserve its delicate texture from the least derangement.

B. You observed that the exhibition of sensitive and intellectual powers is mysteriously connected with the brain. Did you mean that the mind itself is only a certain property or quality of the animal brain?

A. No. Only that certain injuries to the brain seem to disturb the senses, and to produce insanity or stupidity. So one's sense of seeing would be impaired or destroyed, to appearance, if his *spectacles* were smoked or broken; though the real difficulty would be, not that the faculty of vision itself was injured, but only the instrument by which that faculty is enabled to *shew* itself, was rendered incapable of performing its duty. Thus it may be, in the present appearance. The brain is the *instrument* of the mind; and when the instrument is affected, the mind, to all appearance, is affected too. But then, it is easy to show how it may be *only* appearance.

B. I believe I understand you.

T. I am happy you do in so few words; for I do not wish you to enter upon any metaphysical speculations at present. We will reserve these for another opportunity. I want you now to confine yourselves to the consideration of the wisdom and goodness of

the all-bountiful Creator, as manifested in the *visible* frame, and in those things which are subjected to the notice of our *senses*. You was speaking of the delicate texture of the brain, and what striking instances of care may be seen in the provisions which are made for its preservation and security.

B. First, I wish you would give me some idea of this organ.

A. It is a soft substance filling the hollow of the head, composed of various parts differing in texture and figure, but unknown in their uses.—The two principal divisions of this organ are called the *cerebrum* and *cerebellum;* the former occupying the forward part of the head, and the latter, the posterior or hinder part. What is called the *spinal marrow*, is a continuation of the brain into the hollow of the back-bone, and is extended down through its whole length. From this most of the nerves of the body are given out. Gall and Spurzheim maintain that the fore part of the brain has a particular connexion with the intellectual powers; and the back part, with animal propensities.

T. This will suffice. We are now confining our attention to exhibitions of design, and not going into mere descriptions of parts. Taking for granted, what it will require no argument to prove, the peculiar *importance* of protecting the brain, on account of its being the most delicate and essential organ in the animal frame, you may mention some of the principal provisions, in which we are led to admire the displays of ingenuity and contrivance, if we may so express it,

for this purpose. They are very remarkable, and you may be somewhat particular.

A. Anatomists speak with admiration of the carpentry and architectural contrivances exhibited in the head, for the security of the brain. In the first place, the skull is a hollow bone. A carpenter cases a delicate article in a close, firm, solid box. It is the more remarkable in the skull, because a bony case is not the covering which is generally adopted in the body. All the great cavities of the system are principally *sacs*, formed chiefly by skins or membranes. But the one which encloses the brain is *hewn* out of a bone. The heart, the lungs, the stomach, the bowels, are not equally tender, and have no such security. We can see the wisdom of this arrangement. But we discover no *natural* reason for it, besides design.—The brain requires a stronger protection. Its supreme delicacy and importance render such a protection necessary. But this is no cause *why* a more solid case should surround it, except as we refer to the agency of an intelligent Contriver.

B. So the strength of the cover is proportioned to the tenderness of the substance which is lodged within it.

A. The brain is not only protected by a solid case, but is enclosed in a case *by itself*. The heart and lungs occupy one cavity together; the liver, stomach, spleen, intestines, are packed in another cavity below it. They are not of so soft and delicate a consistency as to be disturbed by each other's motions, or a slight degree of compression. But the brain is

of such exquisite tenderness, that it would be injured by the least pressure of surrounding parts. The skill of the architect is here displayed, in causing the brain to occupy a separate apartment.

B. How striking when it is mentioned! and yet I doubt whether one person in a million has ever thought of the circumstance.

T. Perhaps not; and yet, I presume, nothing is more true, than, that if the brain had been placed in the chest, or in any such situation as is assigned to the other vital organs, the pressure upon this tender substance would have been instantly fatal. Do you think of any evidence of design in the form of the head?

A. *Round* vessels are the least liable to be broken, or pressed in. Thus—a thin watch-glass, because it is rounded up in the middle, will bear a very hard push. A full cask may fall with impunity, where a square box would be dashed to pieces. A very thin, globular flask or glass, corked and sent down many fathoms into the sea, will resist the pressure of water around it, where a *square* bottle, with sides of almost any thickness, would be crushed to atoms. The common egg-shell is another example of the same class. What hard blows of the spoon or knife are often required to penetrate this wonderful defence, provided for the dormant life, or living principle, contained within the egg!* The arches of bridges, the roofs of houses, the helmets of soldiers,

* Arnott

&c., are all constructed upon the same principle. This is not only the general form of the case which has to cover and protect the brain; but, wonderful to think, the head is most rounded precisely in those places, where, in falling, it would be most likely to strike the ground. These are, the middle of the forehead, the projecting part of the head behind, and the upper portions upon each side, or those least protected by the shoulders. Anatomists also observe, that just in those situations where a carpenter strengthens his roofs by braces, there the roof of the skull will be found to be strengthened by strong ridges of bone on the inside, which answer the same purpose.

B. Any one may perceive, that the round form of the head is the most beautiful, but few, it is probable, have ever thought of any other advantage.

T. But this is a small part of the wisdom displayed in this wonderful structure.

A. The skull is a double case; and may be compared to two bowls, one within the other. The outer bowl is a tough and woody kind of bone. The inner bowl is of a much more hard and brittle texture: anatomists give it the name of *vitreous*, from a Latin word which signifies *glass*. What completes the contrivance, there lies between, a corky, spongy kind of bone, anatomists call it the diploe,—and each of these particulars has its advantage. Our kind Architect seems to have contemplated several distinct securities in this structure, which are made necessary by different and not infrequent dangers to which we are exposed. It is readily seen, that one familiar danger is,

that of the head being pierced through by any penetrating body, as a fork, a penknife, the corner of a stone, &c.; and hence the advantage of a hard and glassy cover about the brain, capable of turning the edge of any sharp or pointed instrument. But then, a covering hard and glassy throughout would be subject to be chipped and cracked continually. Under these circumstances, the double case is plainly the true mechanical contrivance, that is, an *inner* bone calculated to resist any cutting or pointed body, —*plated over* with another, less subject to be scaled or splintered by strokes upon the outside. Such is the architectural contrivance exhibited in the skull.

B. Who could ever have supposed all this to be accidental! If a man's ingenuity were to be exercised in contriving a protection for the brain, it is difficult to say how he could have obtained the object better. It seems as though there could be no danger now from any common accident, except the brain might be liable to be jarred by blows or falls occasionally.

T. These blows and falls, however, are apt not to be very infrequent; and the brain is so tender and sensitive an organ, as might render even a jar a very serious affair. A celebrated anatomist observes, that a blow upon a man's head, by a body which shall cause a vibration, (or jar), through the substance of the brain, may more effectually deprive him of sense and motion, than if an axe or a sword penetrated into the substance of the brain itself. There is, in several respects, a remarkable structure of the head, adapted

to this very danger. In most of the instances, the structure has reference to other advantages, but it is suited in every one to the advantage of which we are now speaking. What have you learned upon this subject?

A. The globe of the head is composed of several bones. They admit, at birth, of being easily separated; and during youth and up to the period of manhood, the seams or joinings of the pieces are still loose. Now, it is apparent that unless the union of the joints of any vessel is absolutely solid, as much so as in any other part, it must tend to prevent a ringing, or jar, from extending through. Hence it is, that the slightest disunion in a piece of ware may be detected by a stroke of the knuckle, which could not else be discovered; the flaw impedes the vibration, and this affects the sound. There is reason to believe, that in early childhood, especially during the lessons of walking, this is one cause why falls are borne with so much impunity. *(Arnott on the Elements of Physics.)* But anatomists mention another security; the more curious, because it has so precise a resemblance to a kind of precaution we adopt ourselves in similar cases. The skull is lined within, like a soldier's steel cap;—one advantage of which lining to the soldier is, that it diminishes the jar occasioned by the sword, and which would be capable of bringing him to the ground without any penetration by the weapon. The effect may be seen in a wine glass, which will not ring if we but touch our finger upon the cup. There is the same principle of security in the bony case, which

surrounds the brain, and which is termed by anatomists, *cranium*, from a Greek word signifying a *helmet*.

B. So, without knowing it, we have made our helmets to cover the head, upon the very principle upon which the head itself is constructed.

T. Yes, and in another circumstance quite as curious as this.

A. The helmet is not only lined with leather, but covered with *hair*, which is said not to be intended for an ornament merely, but is an essential part of the protection. It breaks the force of the blow, and lessens the agitation of the metal. Nature has done the same. The advantage of the hair is two-fold. It tends to prevent any tremulous motion in the skull, upon the principle of a coating;—and besides, furnishes the general benefit of a cushion for the head; for which it is eminently fitted, it being the very material of which cushions are usually made, on account of its particular excellence as a springy or elastic substance. Such are some of the uses which the wisdom of nature has contrived to unite with this beautiful ornament.

B. It appears, then, that the greater abundance of the hair, when we are young and heedless, is no unimportant circumstance.

A. There is one practice with regard to children, however, that would not seem to accord very well with this provision of Providence,—I mean that of rocking them to sleep. The violence with which this mechanical anodyne is often applied by the impatient nurse, argues no great sensibility, one would think, in the brain of the infant.

T. It is possible that the *regularity* of the motion, like that of musical sounds, may have a lulling effect, and, so far as this cause is concerned, no injury perhaps may arise. But you may be aware, the practice is, after all, objected to by some medical writers. They say, that sleeping should be purely natural in a healthy infant, as it is in after life, and not induced by the stupifying effects of any artificial means.

You spoke of the skull as composed of several bones. Is there any thing remarkable in the manner in which they are united?

A. It is surprising, anatomists observe, to see how the pieces are joined in the best possible mode for security. The edges, where the bones unite, are cut into little teeth, in a sawlike manner, and interlock closely with one another, so as to produce the firmest joint. It resembles that strong mode of uniting which is called the dovetail,—or, more exactly, it is the foxtail joint of the carpenter, which he always employs for strong work, when the pieces are small. Anatomists call it a *suture*. It makes the crinkling lines which may be noticed on the outside of a dry skull.

Fig. 1.

a, one of the sutures on the outer portion of the skull.

B. Are there no other bones which are united in this manner?

T. None; it is only in the skull, that it would be found useful.

B. It is not the nature, then, of bones, as such, to grow into one another in this dovetail form, but it is confined to the brain case.

T. And hence, no doubt, you considered the *design* more conspicuous, that there should be an exception for a *single* instance, and the only instance in which it is required. If you know what is meant by a dovetail joint, you are aware it only prevents the parts which are united, from being *drawn asunder.* The form of the joint does not secure them from being *lifted up,* or *crowded in,* out of their places. The mechanical contrivance for this purpose, as a carpenter would say, must be a rabbeting or lapping of the edges. What do the anatomists tell you as to this matter in regard to the head?

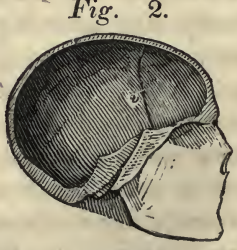
A. That if a carpenter were to inspect this ingenious work, he would be struck with observing that every bone overlaps the adjoining bone at some points, and at other points it is itself overlapped by them; so that it is literally impossible that any bone should be driven in upon the brain without absolutely breaking it, which requires a great degree of violence.

B. One must be quite a mechanic, I perceive, to understand this surprising structure.

A. Anatomists further invite attention to another particular. The teeth, which form the *sutures,* are said not to extend *through,* that is, the processes or

juttings out between the bones, and by which they are interlaced, are observable only upon the *outer surface*, which belongs to the tougher, woody bowl of the skull. On the *internal surface*, the pieces are laid together in a manner more nearly approaching a smooth line. This mode of joining is called by anatomists, *harmonia*, or harmony. The same joint, and the same name for it, are used by architects in masonry. This is pronounced remarkable, because it is so plain, that, while the superior toughness of the external surface will better admit of uniting by a dovetail edge, as carpenters do in their work, the brittle nature of the inside is not so suitable for this species of joint: "as if a workman in glass or marble," says Dr. Bell, "were to enclose some precious thing, he would smooth the surfaces and unite them by cement, because, even if he could succeed in indenting the line of union, he knows that his material would chip off on the slightest vibration." Such is the ingenious and provident structure of the skull.

Fig. 2.



b, one of the joints upon the internal surface of the skull.

B. One would think anatomists must be the most devout persons in the world, when they know so

much more than others, of the wisdom of the human frame.

T. I could detain you much longer, however, upon this wonderful workmanship.

B. No particular can be uninteresting, where the hand of a Divine Architect is seen.

T. Do you know the use of those iron pieces, in the shape of the letter S, you will often see on the outside of brick buildings?

B. I presume they are connected with the beams upon the inside, and serve to keep the walls from spreading apart.

T. And you must be sensible, as the dome of the head is composed of several bones, in case of a violent pressure or blow upon the top, some security might be useful for the same purpose. It is said, that when a man falls, so as to strike the crown of his head upon the ground, if the skull yields, it yields in the temples, or it spreads out at the bottom of the dome; just where any other dome would *spur out*, should the roof be too heavy for the support. Now, is there any architecture of the head, that manifests a knowledge of this danger?

A. Anatomists describe a remarkable structure which evidently contemplated it: wonderful as it may seem, there is a bone, called the *sphenoid* bone, which runs across the bottom of the skull, and turns up with a plate at each extremity, so as to overlap the walls upon the outside. The plate, (see *b*, in *Fig.* 1.), is thin in the head, but stronger, compara-

tively than that which is used for the security of a brick wall.

B. There seems to be no species of contrivance but what is exemplified about this admirable architecture—and the more remarkable in the present case, as there can be no natural tendency in the pressure of the walls of the head to create *tie pieces* upon each side, but the reverse: as well might we say, that the pressure of the dome of St. Paul's Church in London, has made the double chain which encompasses it around the bottom to hinder it from spreading.

T. And you are aware this is the very object we have in view, to show a creative Intelligence by displaying actual and original purpose and contrivance, in our frame, such as can only be referred to design. You may mention some other particulars respecting this wonderful mechanism.

A. The head is lined with a thick, firm membrane, called the *dura mater*, and this lining is also lined with a thinner membrane termed the *pia mater*, —*pia*, (from one of the meanings of the word), tender, affectionate.

B. Then, there is a softer wrapper in contact with the brain, and a firmer one upon the outside.

T. Precisely the same mode we adopt ourselves, in packing a precious article of which we wish to be very careful.

B. Excepting the danger of some great violence, against which no security could avail, it does not seem possible to conceive what more could have been done

in this wonderful piece of mechanism, to fit it for the purposes it has to answer.

T. There is, at least one happy circumstance more, deserving to be mentioned, and that is one which contributes to the safety of the brain, even when the head is broken in. Can you describe it?

A. The principal lining of the head, which anatomists call the *dura mater*, (*dura*,—hard and unyielding, to signify its strength), is so substantial a membrane, that when the skull is *fractured*, it is not easy for the pieces to fall in. In this respect, it may be compared to the skin upon the outside of an egg, which we often see preserving the form of the egg entire, when the shell is broken in a thousand pieces. But for this, the surgeon would rarely be able to raise the fragments of a skull without fatal consequences to the brain. This lining is found also in the spine, which contains a continuation of the substance of the brain. We discover no such lining in the hollows of the other bones. They contain nothing which requires it.

T. You spoke of the packing of the brain as remarkable. There is another instance, more curious still, of the same kind.

A. There is a place where the membranes that enclose the brain suddenly turn inward, and divide it into two parts, so as to prevent one part from pressing upon the other. The partition takes place in a remarkable situation. It is where that portion of the brain called the *cerebrum*, and which occupies the forward and upper part of the head, begins to descend

upon the other portion, viz. the *cerebellum*, which lies in the lower and hinder section of the box; the consequence of which would be, that one would compress the other, if it were not for the partition between. In ravenous animals, whose brain is subject to violent motions from leaping, &c., the partition is said, for the most part, to be nearly, or quite, of the consistency of bone.

Fig. 3.

a, the cerebrum. *b*, the partition, or falx, separating the two lobes or divisions of the brain. *c*, the cerebellum.

B. What an astonishing resemblance to art! We often see boxes containing a variety of precious wares, parted off in this manner, where one must not be permitted to be crowded by the others around it. There seems to be no ingenuity but what is exemplified in the construction of this wonderful case.

T. Is the head the same from infancy to old age?

A. The changes are exceedingly remarkable. At birth, the bones are said not to be locked together at all. They are separated by *membranous* or skinny spaces between them, so that they can overlap each

other considerably, and suffer the head to be reduced in size. Besides this, there is another difference. As we advance into declining life, the whole skull becomes more like one uniform bone, when our own care and our usual aversion to personal exposures, render the securities of nature of less importance to us. "The alteration in the substance of the bones, and more particularly in the skull," says a most distinguished modern anatomist, "is marvellously ordered to follow the changes in the mind of the creature, from the heedlessness of childhood to the caution of age, and even to the helplessness of superanuation."

B There seems to be no end to the wonders of this curious box. Who would have thought of the skull's changing its structure and texture to suit different periods of life! We have only to lift our hand to our heads to be persuaded of a Divine Architect.

T. Can we trace any particular wisdom in the different form of the head in different parts?

A. The strongest form is at the back. Here the head is the most rounded. Here also the skull is particularly thick; and besides both these provisions, there are strong ridges of bone upon the inside, which render it incapable, or nearly so, of any crack. It is by far the strongest part of the head. Now, what is remarkable, it happens to be the most exposed part, as to being liable to the heaviest blows, from falling backward. In short, here is that marked and distinguishing species of foresight, in which a distant danger is taken into view; that is, in which the structure of the *head* is adapted to the accidents of the *feet*.

B. Now we can understand why what always seems to be so dangerous should be attended with no more injury, the falling of boys upon the ice, as if they would sometimes beat their heads in. It is indeed a beautiful fact, that the part of our head which cannot have the protection of our hands, when we fall, should be particularly guarded by the make of the head itself.

A. We further observe, in this wonderful combination of precautions, that the temple bones, which are the *thinnest* part of the box, are placed directly over the shoulders, which secure them in case of a fall; and, besides, are a little flattened in within the general circle of the head, which preserves them still further from any blow; and what is again remarkable, are composed, anatomists say, of the hardest bony matter in the whole body. "Generally it is observable," says Dr. Bell, "of the whole structure of the head, that those parts which would be most apt to strike the ground when a man falls are the strongest."

T. Anatomists speak of a remarkable display of design in regard to preserving the brain from the pressure of the blood.

B. I can easily conceive of this danger. I have frequently felt a disagreeable sensation after running or stooping, as of a fulness or pressure in the head.

T. Apoplexy, the most fatal of all disorders in the brain, and which is generally occasioned by the bursting of a blood vessel, or the interruption of the passage of the blood in this delicate organ, has been known to be brought on by persons whose vessels

happened to be more crowded, or more feeble than common, bending the head down in the act of tying a shoe or drawing on a boot. Children and tumblers, being much in the habit of placing their bodies in all positions, feel no inconvenience from having the head downwards, because blood vessels always become strong enough to bear the pressure to which they are *habitually* exposed ; but to many old people accustomed to keep the head always upright, the attempt to imitate such feats would be dangerous. This will lead you to appreciate the remarkable provision to which I alluded. Can you describe it ?

A. The principal blood vessels which carry up the blood into the brain, and about one tenth part of the whole blood in the body, it is said, is thrown into that organ, are so contrived, that the force of the stream, and it is thrown with a smart stroke, owing to the nearness of the heart, is principally spent against the bone of the skull. The provision is this. The main artery of the head makes a sudden turn in the base of the skull, by which the force of the current is broken, and then distributes itself over the brain ; the consequence of which is, the discharge is made against the bony walls of the skull. It is like a stream of water from an engine, striking against the side of a building, which being done, the water drips down or diffuses itself without any considerable violence. In quadrupeds, the position of whose heads, being nearly upon the same line with their heart, exposes the blood to flow with more force into the brain, the blood vessels, where they enter the skull,

are previously divided into a number of little branches, which, by multiplying the channels, diminishes the rush of the stream.

B. I shall never feel a throb in the head again, after any violent exertion, without thinking of these admirable securities.

A. The principal vessels which bring the blood back from the brain are also a curiosity of contrivance. What is extraordinary, they differ from all other veins in the body which are used for returning the blood to the heart. It is plain, the blood ought to have the freest and easiest return possible from the brain. Any obstruction would be followed by the most serious consequences immediately. "Therefore, it is one of those particulars which powerfully affect a contemplative mind, as proofs of a designing intelligence," says a late eminent writer, *(Arnott on Physics)*, "that the chief channels which return the blood from the head, are not common compressible veins, (the common veins are skinny or membranous tubes, easily pressed together), but they are what anatomists call *sinuses*, or grooves in the bone itself, with exceedingly strong membranous coverings, supported so powerfully, that the channels become in strength little inferior to complete channels of bone."

T. There are many varieties adapted to the nature and circumstances of different animals. The head most nearly resembling the human is that of the monkey; but there are several respects in which the similitude fails, as may be seen in treatises upon comparative anatomy

The head of the elephant is remarkable for containing uncommonly large vacuities in the frontal bone, which render the enormous mass of the skull much lighter and more easy to be borne in proportion to the bulk than that of many other animals.

THE SENSES.

T. Besides the *mechanism* of the head, what other marks of design are mentioned in this wonderful structure?

A. That it is the seat of the principal senses, such as sight and hearing. We know not why they should be situated here, or why the eye and the ear are not on some lower part of the body; except, as having to take notice of distant objects, they require the highest situation they can have, to enable them the better to perform their duty. But this is no reason for their having this situation, as we can see, only as we take into view an Architect, who was aware of the advantage. Again, the eye looks forward in the same direction with the motions of the hands and feet; but for which circumstance, the eye would have been of very little use to us; and yet there was a whole circle of positions around the head, in which it might have been differently situated. Let a child only reflect upon the inconvenience of having his eyes upon the side of his head, as over his ears, for

example ; that is, of being compelled to look in one direction and walk in another. The senses of sight and hearing are given us in pairs ; so that if one eye, or one ear should fail us, the duplicate may still answer our purpose. None of the senses are single. None of them are confined to one solitary spot of the body, so as to be made dependent upon the safety of that particular spot.

T. Does not the same wise arrangement appear in the situation of the other senses ?

A. The situation of each is adapted to its use. The sense of *smell*, which makes us acquainted with the presence of odors, of which the air is the vehicle, is placed in a continual *current* of air ; that is, in the nostrils. In this situation, it not only best enjoys what is agreeable to it, but by thus occupying one of the main passages of the breath, it is enabled to perform the important office of apprizing us of the entrance of any unwholesome effluvia into the lungs ; air unfit for respiration being usually offensive to this sense. As most substances are also distinguishable by their odor as to their being fit or unsuitable for food, especially, it is said, in dumb animals, it is striking to observe that the position of the smell is immediately over the passage where every thing must enter that we eat. The sense of *taste*, discovers the same evidence of design. We can assign no reason why it is placed within the cavity of the *mouth*, except, that to enjoy our food, the faculty of tasting it must be situated where the food is broken ; and not only so, but where the food is received, and

masticated ; that is, not *over* the mouth, but *within* it. The sense of feeling completes this wonderful arrangement, by having no particular situation assigned to it. Being spread over every part, it warns us of dangers of which we could not have been apprized by our other senses. It would have been exceedingly unfortunate, if we must have had to *see* every nail and splinter before we could draw back from a dangerous puncture ; or could only know we were scorching up, by observing the smoke. We can offer no natural explanation why *this* particular sense happens to be extended over the whole body. The eye can perform its duty from one little spot in the head ; and why the sense of feeling should not have been confined to the head also, we can only answer, because it is a sense which cannot perceive at a distance, but must be *present* at every part, where its office is required.

T. You might have added another fact respecting feeling, or, more properly speaking, the *touch ;* that it is the most nice and delicate, where we have the most occasion for its use, viz. in the ends of the fingers ; though it is said to be *more* delicate in the tip of the tongue.

B. Is it not stated that there are more nerves, in proportion, in the fingers, than in most other parts of the body ? and we use the sense of touch more in this part also, which must tend by practice to render it more perfect.

T. The mechanism of touch exists in perfection in the *ball* of the finger. But whatever the reason

may be of the superior delicacy of the power in this part—and there are several reasons, the fact is a happy one, especially for blind persons. No doubt you have heard of many curious instances.

A. The blind have been said to detect a joint by the finger, which others were unable to discover with the eye. It is mentioned, they are now learning to read print merely by feeling the indentations made upon the paper by the types.

B. Have they not also been said to feel colors? though this seems incredible.

T. As every color requires a different substance to produce it, it is only supposing every coloring matter to be different in the shape or arrangement of the particles of which it is composed, to account for an extreme delicacy of touch being able to distinguish it. You have spoken of the touch as becoming improved, when other senses are wanting. Is this compensating providence confined to the touch?

A. It extends to all the senses. It has been observed of persons who have been deprived of any particular sense, that peculiar power and delicacy seem bestowed on those which remain. Thus, blind persons are not only often distinguished by the exquisiteness of their touch; but, the deaf and dumb, who gain all their knowledge through the eye, are remarkable for the keenness with which they make use of this channel of observation.

B. I should think one of the most extraordinary instances, if we may judge from recent accounts, might now be found in our own country. It is men-

tioned that there is a pupil in the Hartford Asylum, *who is entirely deaf, dumb, and blind*, and her *touch* and *smell* are so exceedingly heightened, especially the *latter*, that it seems to have acquired the properties of a new sense, and to transcend even the sagacity of a spaniel. At her first reception into the Asylum, she immediately busied herself in quietly exploring the size of the apartments, and the height of the stair cases; she even knelt and smelled fo the thresholds; and, now, as if by the union of a mysterious geometry with a powerful memory, never makes a false step upon a flight of stairs or enters a wrong door, or mistakes her seat at the table. Her simple wardrobe is systematically arranged, and it is impossible to displace a single article in her drawers without her perceiving and restoring it. She executes the most beautiful work; she gathers the first flowers with a delight bordering on transport. Without ever having been sick herself, she so readily comprehends the efficacy and benevolence of the medical profession, that she has been known, upon a physician placing her finger upon her pulse—to lead him immediately to the chamber of one of the pupils whose absence by sickness she had mysteriously detected. She distinguishes the return of the Sabbath—and appears sacredly to observe it, as those intimately acquainted with her habits assert.*

T. And all this merely by the aid of two senses, the *touch* and the *smell!* What a comment upon the

* Mrs. Sigourney's very interesting account in the Juvenile Miscellany.

inward powers of man, when they can accomplish so much with so little external intercourse, or perception. But speaking of the sense of feeling, are not many parts of the body so exposed to be chafed and worn away by severe rubbing, as must be apt to render the delicacy of this sense very painful to us?

A. There was an evident foresight of this very difficulty; and it is curious to see how it has been provided against. The sailor covers his ropes with leather where he knows they will be likely to be frayed. He always carries leather to sea with him for this purpose. But this is nothing to what nature has done. We may notice her contrivance upon the bottom of the heel. It is *the scale or crust we there observe*, and which is produced altogether by the constant rubbing and pressing of the foot in walking, as infants have no such cases upon their heels. We see the same, or what resembles it, in the hands, and wherever the skin is subjected to hard usage. By being tender of the part for a short time, the case disappears, and the skin returns to its ordinary state. The leather comes upon the rope, *of its own accord*, and gradually goes off, as it ceases to be wanted.

B. What a happy provision, especially for the poor laborer! The rock is made to give him his gloves.

T. Are there any remarkable varieties in animals, with respect to the senses?

A. It is observable that in the fish the organs of smell are placed on the *outside*, at the extremity of the *muzzle*, so as to receive impressions from the

water, as the fish swims forward. It is also noticed that the animals which have the sense of smelling in the greatest perfection, are those which live by hunting, and have occasion to trace their prey to the greatest distance.

THE EYE.

T. What evidences of design may be discovered in the eye?

A. If any instrument may be said to exhibit contrivance, it is this admirable and beautiful little organ. The eye is made almost precisely upon the model of a telescope or spying-glass. There is the same general kind of mechanism; the same principles applied; the same knowledge discovered of the laws and properties of light; only the construction of the eye is much more ingeniously adapted to these laws, and parts for the same purposes are contrived to much better effect, than in any other telescope. In short, an eye taken to pieces, for this is necessary to form any idea of it, is such a wonderful spying-glass, that it has taught the best telescope makers how to improve their own instruments. It discovers several curious contrivances, of which the most skilful artists had never dreamt. Some of them are so wonderful, that we shall probably never be able to imitate them;

but they will always leave the eye, it is likely, the most finished instrument of the kind, that ever was or ever can be made.

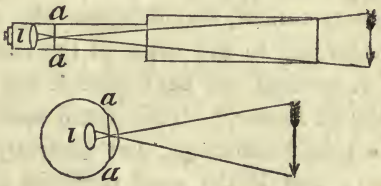
B. One must be quite learned, then, about telescopes to understand the construction of the eye.

T. The more learned the better; but every one must understand enough for the present purpose. If you have ever pulled out the tube of a spying-glass, and unscrewed the joints, you know it contains several little rounded glasses;—it is these glasses that make the telescope. The eye is just such another instrument; so that when we are espying, we may say there are two telescopes,—the one in our hand, and the other in our head; and the use of the one *without,* is to assist the one which is *within* in seeing further. They are both constructed on the same principles. You may describe the eye.

A. The principal parts of the eye are, as in other telescopes, rounded glasses, or substances which resemble them, and which answer the same end, though they are not of glass. They are all situated in the ball. The front of the ball is covered with a transparent skin, which is termed the *cornea,* from a Latin word signifying *horn,* because it has a certain resemblance to a very delicate shaving of this substance. It is a little thicker in the middle than towards the edges, and has in a degree the same effect as a magnifying or telescope glass. Next to this is a fluid, commonly called the *aqueous humor,* and which will run out when the eye is pricked. It derives its name from the Latin word for water. It fills the forward

part of the ball, and is kept in a round form by the shape of the eye. It serves the same purpose as the magnifying glasses which are used in telescopes; it being well known that a round drop of water will magnify like a piece of glass of the same shape. Next, and immediately behind this *water glass*, if we may so term it, we come to a curtain, called the *iris*, stretching entirely across from side to side, with a small round hole in the middle. This hole is named the *pupil*. We see the same in a spying-glass; it being found to increase the clearness of the sight, when the light passes through a little aperture. In telescopes the contrivance is what the instrument makers call the *field*. This is a plate of brass inside the tube, perforated in the middle with a small round hole directly in a line with the centre of the glass before which the *field* is placed. This contrivance is found to improve the instrument by not permitting

Fig. 4 & 5.



A telescope glass, *l*, with its curtain before it, *a a*, in which there is an aperture at the centre: being a precise imitation of the eye, where the same parts are indicated in the Figure by the same letters; viz. *l*, the principal glass of the eye, called the chrystaline; *a a*, the iris, with the pupil in the middle.

the passage of any light but what enters about midway of the glasses. To this structure there is a wonderful resemblance in the *natural* telescope; the *iris* being the field; and the *pupil* answering to the little aperture in the field, it being exactly before the centre of the principal glass of the eye. (See *Fig.* 4 and 5.)

But the hole in the eye, which is called the pupil, is made to answer another purpose. It enlarges or contracts, to suit the quantity of light, so that in a bright sun too much light may not be admitted into the eye; which would be painful and injurious. If we examine the eye of a person by bringing up a candle, we shall see this opening diminish, as the light increases; or, if we darken the eye with our hands, and suddenly remove them, we shall notice the same effect. The curtain, which we term the iris, has, in different persons, different colors around the pupil in front, making that painted circle we observe in the middle of the eye; in some people, black, in others, blue, &c. It has been remarked, that it is generally either light or dark, according to the color of the hair. Behind the pupil is situated the next glass of the eye, called the *chrystaline humor.** This is still more rounded; and is of a gristly substance, but perfectly clear and transparent; and is the most powerful glass in the

* A small portion of the aqueous humor is situated between the pupil and the chrystaline; but this is not of essential importance in the present description. One use of this intermediate water is supposed to be, to moisten the iris, and enable this important curtain to perform its office with more ease.

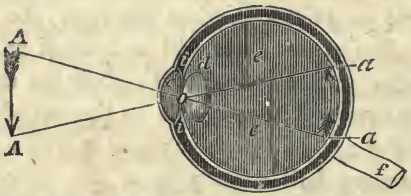
eye. It is the little ball we take out of a fish's eye. Immediately behind the chrystaline, is situated the last glass of the eye, something in the shape of the water glass in front, and is called the *vitreous humor*, from its resemblance to melted *glass*. The light, by passing through all these glasses, so to term them, is drawn to a little round spot, such as is made by a burning-glass; and this spot contains an image of the object at which we look. Thus, if we hold up a a spectacle or telescope glass between the window and a sheet of paper, there will be a small bright spot on the paper, and in that spot we shall see the image of the window and the objects on the outside. The glasses in the eye do the same; and it is so contrived, that the image falls exactly upon the delicate substance of the nerve which is spread out on the back part of the eye, like a sheet of paper, and is called the *retina*. If the skin on the hinder part of an ox's eye be carefully removed, and the eye be held up to the window, the images of objects in the street will be seen distinctly painted on the back, where the retina is situated. If any injury happen to the eye to prevent the image from being formed, we are unable to see. This, therefore, is the demonstration of design,—nature requiring an image for the purposes of vision, has furnished an instrument perfectly adapted to produce it; a mechanical and complicated instrument; in short, a literal telescope.

T. You spoke of the roundness of the eyeball. Is it a perfect sphere?

A. Not exactly. The front projects beyond the general curvature. The effect is, the compass of our vision is enlarged, and we can see further around us, than if this part of the eye were not so protuberant.

B. What a multiplicity of provisions for the perfection of this beautiful and noble organ.

Fig. 6.



e, aqueous humor. *i*, *i*, iris. *o*, pupil. *d*, chrystaline humor. *e*, *e*, vitreous humor. A, *a*, rays of light crossing at the pupil, and passing from the object A, A, to form the image on the retina, *a*, *a*. *f*, optic nerve.

T. In speaking of the pupil, do you remember what is stated as to the contrivance by which it is always kept in a round form?

A. The constant exactness of the circle, notwithstanding its changing its dimensions almost every moment, has been always mentioned as a curious phenomenon. No artist would find it easy to imitate this contrivance. It has been supposed to be effected by means of fibres or threads in the iris, so arranged with reference to the central opening as to enlarge or contract it like a purse; though some anatomists are not entirely satisfied how it is produced. They say the

apparatus is so delicate and obscure that they cannot decide upon its true character.

B. There must be some wonderful mechanism about this aperture, the membrane of the iris must be exceedingly sensitive to feel every change of the light so immediately.

T. Why, here is another remakable fact, which shews what amazing design runs through every part of our structure. The changes in the pupil are to benefit the retina, so that too much light may never fall upon this tender substance. Now, as the retina is the part to be benefitted, it is evidently desirable that *this* should have the management of the pupil by which the light is admitted. Had the curtain, or iris, which contains the pupil contracted or enlarged the opening by any sensibility which it has *itself* to the light; and this, till recently, has always been supposed to be the fact; it is easy to see, that the tenderness of the retina might sometimes be greater or less, than that of the curtain, (for it often varies),—and would consequently be liable to suffer. Do you recollect any notice of this particular?

A. It is said, by a late valuable writer,* to have been ascertained by a very delicate experiment, that if a ray of light be admitted into the eye in such a direction as only to strike upon the iris or curtain, without passing through the pupil—the pupil is not affected—no change of the aperture takes place; but if it enter the pupil, and thereby fall upon the retina, a contraction immediately ensues. The sensibility is

* Dr. J. Ware, of Boston.

lodged not in the *contracting* part, but in *another* part at a distance from it, for whose benefit the provision is designed.

B. It seems like one holding a screen which he spreads or folds according to the wish of the person whom he is protecting. No wonder it should be said, the eye is a cure for atheism. We can suppose the Almighty Creator could have enabled us to see without all this machinery;—but then, observing the machinery makes us more sensible of an actual Architect in our frame. Still there appears to be one difference between the eye and a telescope. If we look with a telescope or spying-glass at a far object, as a vessel upon the ocean, and then turn it to a person standing by us at a few feet distant, we find we are now unable to see: but it is not so with the eye. Our sight is not affected by any moderate change of distance. What can be the reason?

A. The reason is, and it is a new reason for admiring the eye, that the spying-glass requires to be altered, or fixed anew, before we can see a near object, after looking at a distant one. Now this is done in our eyes in an instant. In the spying-glass, we have to pull out or thrust in a tube, so as to change the distances of the glasses from one another,—or else put in glasses of a different form. There is exactly the same or a similar contrivance in the eye. It is difficult to describe it, it is so exceedingly curious, But the effect is to enable the eye to suit its glasses immedialely to the different distances at which we have occasion to look.

B. It must be very perfect; when we think how quickly we can glance from one object to another,—from surveying a *star* to threading a *needle.* Still, one would hardly have thought there was occasion for all this machinery to enable the eye to do what it appears to do in such cases, without any exertion;—and yet we can feel there is some apparatus at work about our eyes, which seems to strain when we try to look at an object close up to our faces, or at a very unusual distance.

T. We have had a wonderful account of this organ of the eye. But it is worthy a more minute description still. Its Divine Architect has introduced contrivance upon contrivance, to render it the most surprising telescope that was ever made. You may go on with the description.

A. In telescopes it is necessary, and the discovery is a somewhat late one, that the glasses should not all be of *one kind* of glass. Though most persons are not in the habit of observing it, for it requires a close attention, yet it is a truth with regard to every telescope or magnifying glass, let it be formed of what kind of glass it may, that it produces a *rainbow* appearance, or variety of colors about the little bright spot or image where the light is collected. The reason is this. "Light consists of different colored parts, as Sir Isaac Newton discovered, some of which are sooner collected by the glass, or more quickly drawn to a little circle or image, than the others; the consequence of which is, when we hold up a burning-glass or a telescope glass to the sun, the lights of different

colors come to a point at different distances, and thus create several circles, which makes a confusion.—This was long found to make our telescopes imperfect, insomuch that it became necessary to make them of reflectors or mirrors, and not of magnifying glasses." But it has since been discovered, that if certain different kinds of glass, viz. flint glass and crown glass, be placed together, so as to make a compound magnifier, they serve to correct this defect. No rainbow is then produced. The improvement was introduced not many years ago, in the celebrated telescopes known by the name of the Dolland telescopes. But it is now ascertained, that the whole discovery was well understood in the first telescope that ever was constructed; that is, in the eye. "It is found that the different natural magnifiers of the eye are combined upon a principle of the same kind." What is more curious, thirty years after the time of Dolland, a discovery was made by Dr. Blair, of Edinburgh, of the greatly superior effect which combinations of *fluid* and *solid* magnifiers have in correcting the imperfection; and, most wonderful to think, when the eye is examined, we find it contains *solid* and *fluid* magnifiers combined, acting naturally upon the same principle which was thus recently found out by many ingenious mechanical and chemical experiments.

B. One can hardly understand so much contrivance; and yet it is beautiful as an evidence of design, and of an *all-wise Author*, to find so much machinery in the eye, which shews the deepest acquaintance with philosophical principles; and to know that

the most celebrated artists have been forestalled and outdone in what they supposed to be their own discoveries and inventions.

T. There is *another* imperfection to which telescope glasses are subject, and it has occasioned much trouble and perplexity to the makers of these instruments, but which affords new reason to admire the hand of a *perfect Artist* in the construction of the eye.

A. The difficulty has been, and it still remains an insuperable difficulty, to make any magnifying glasses, of the usual shape, act equally in every part. The rays of light which pass through near the edge, will come to a *focus*, and form the little circle or image, before those do which pass through the middle of the glass;—and so in proportion, at every intermediate point. This makes numerous images; and although the different images are all sufficiently united in one, for common purposes, yet, in glasses intended for very distinct and accurate vision, it has been found a very serious inconvenience. It is found to be owing to the *form* of the glass, as the form commonly is, which is that of a spectacle glass. This form, it can be demonstrated, has less power at the middle than at the more distant parts of the glass. The attempt has been made, by changing the form, to get rid of this difficulty; and by great skill and attention, the improvement perhaps can be effected. Sir Isaac Newton doubted whether it ever could be perfectly effected. But there is another remedy, though

beyond our ingenuity, it is probable; and that is, as the difficulty is owing to the *form* of the glass not being so powerful in the middle, to increase the power by making the middle of a more powerful kind of glass, that is, of a more *dense* or solid kind. Wonderful as it may seem, this contrivance is actually adopted in the eye. The chrystaline, or principal glass of the eye, is of greater solidity toward the middle. The solidity increases from the edge to the centre. For the glasses in a telescope to possess the same advantage, it would be necessary they should each be made of innumerable kinds of glass, gradually increasing in solidity, from the edge to the middle of the glass. This can hardly be done; and hence the eye exhibits an example of telescopical knowledge and ingenuity which stands unrivalled.

B. This is all new information. If one could not understand a word, it would be delightful to hear of all this curious philosophy in our eyes; because it seems a signal illustration of *divine wisdom and intelligence.*

T. Are there any other respects in which this wonderful organ displays the same sort of superiority?

A. Yes, there is one no less remarkable. The light which comes from an object into a spying-glass or telescope, and by which the object is seen, does not all reach the eye. A part of it is thrown back from every glass in the instrument; and this is no benefit but a disadvantage. But there is no remedy. It is a settled principle with respect to light, that when it passes from the air into a telescope, some of

it will be reflected, or thrown back in this manner; —or, more generally, the principle is this: when light passes from air into glass, or from water into glass—or from any such substance into another of a different kind, though most of it will be transmitted, a portion will be stopped at the surface, and be thrown back or reflected. The glistening upon the surface of a bright window is this effect. The light, in passing from the air into the window, undergoes a reflection, in some measure, at the surface of the glass. It is because the air and the glass are not the same substance. There is the same glistening upon the surface of the ocean; but there is none within the ocean itself; because the water continues the same. How it should fail to be quite considerable in the eye, when there are no less than *three* different kinds of substances through which the light must pass, has been a question. It is stated that there is a most curious and provident contrivance which meets this difficulty. Notwithstanding the three substances in the eye differ, generally speaking, like air, water and glass, though the difference is less; yet, where they touch, and where the light passes from one to the other, and where it must be reflected, if reflected at all, they are nearly of the same substance. The middle one, which is the chrystalline, and which is quite solid toward the centre, *diminishes its consistency* on its two opposite sides, to approach that of the vitreous behind, and that of the aqueous before. Thus, there is less chance for the light to be thrown back or reflected from the glasses; the principle of the reflection requiring that the light, in passing from

one substance to another, should find a sudden difference. Such is the structure of the eye; discovering such perfect acquaintance with some of the most curious properties of light; and uniting philosophical contrivances, various, as they are admirable and inimitable.

T. Speaking of the reflection of the light, do you understand why the inside of a spying-glass is always painted *black* around the glasses?

A. To prevent the glistening of that portion of the light which strikes against the sides of the tube. There is a similar provision in our eyes. The inside lining on the back part of the eye, called the choroid coat, is blackened over with a substance termed the pigmentum nigrum, *black pigment*, or *paint*. In many animals, such as cats, owls, &c., this paint is of a bright color which reflects the light. The precise object of the difference seems yet to be a subject of inquiry. Some have conjectured that it enables the animal to see better in the dark. It has, no doubt, some design. It is ascertained in our own eyes, that if from any cause the black pigment happens to be wanting, the sight is injuriously affected. The singular persons called *Albinos*, from a Latin word signifying *white*, have no such pigment in their eyes; and it is found their vision is extremely imperfect in a bright light; so that they can scarcely see how to direct themselves.

Securities of the Eye.

T. In a telescope it is necessary the glasses should be preserved from the least scratch, dust, or injury; how is this managed in the eye?

A. The principal security is the *eye-lid.* This active little shutter seems almost animated with a sense of the important office assigned it. It closes immediately, as if of its own accord, whenever any thing approaches very near the eye. Every person is sensible how hard it is to keep from winking in such a case, even though challenged to do it if he can. It seems to be one of the *natural* securities provided originally by the all-wise Architect; for we discover the same in infants. It is not, therefore, the result of habit or experience. It is a further mark of design, that the shutter should be made in *two parts;* the eye, of course, is sooner covered by dividing the duty between them; nor is this the only advantage. The *middle* of the ball, being the spot where the light enters, by having two shutters, the one above and the other below, we are enabled to see, and to cover our eyes at the same time: that is, to cover them, all but a little space; whereas with a *single* lid, one half of the front must always have been open and exposed, to enable us to see at all.

B. What perfect mechanism! How admirable the whole art of *divine wisdom* in the formation of this fine organ!

T. Very perfect for a shutter; but still a delicate place for a shutter to be employed. You may judge

of this, by touching your eye with your finger, or letting the nib of a pen fly into it. What is to prevent a constant suffering, with a *shutter* rubbing directly and immediately upon the eye at every wink?

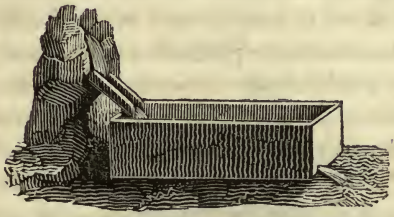
A. A wonderful apparatus evinces how distinctly this danger has been foreseen. An oily liquor is continually oozing out from a row of little glands resembling bags and situated at the roots of the eyelashes. There is also *another* wash: this is thinner and in much greater quantity. We call it the tears. The tears help to *lubricate* the eye; and, besides, answer another purpose. The lids could not have squeezed out the dust; a water was necessary to carry it off. It is found also that when the ball happens to become dry, it loses its clearness and transparency in some degree. Now with reference to *both* these uses, it is admirable to notice how many little circumstances are made to increase the tears, when the tears are the most wanted. Thus our eyes *water* the most in the wind, which would otherwise immediately dry them;—and any offending body falling into the eye produces the same effect.

B. The flow of the tears is an exquisite contrivance; but what becomes of the wash? It cannot remain pure for a long time.

A. To complete this wonderful structure, there is a provision for *this* also. There is situated at the inner corner of the eye, an outlet which empties into the nose, and by which the tears are discharged. It is the same contrivance as the *dripping hole* to a water trough, which continually carries off the water,

and permits a constant renewal from the fountain.

Fig. 7.



A reservoir for water—exhibiting the fountain and outlet.

This outlet in the eye is furnished with two small orifices, which the anatomists call *puncta lachrymalia*, or tear holes. The water is conducted along within the eye by a structure of the lids, not very easy to describe; but entirely mechanical, and the effect of which is to incline the tears to run easily to the opening. The *winking* of the lids is a part of the contrivance; it presses the water toward the place of discharge; and hence the quickened motion of the eyelids when persons are endeavoring to conceal a *tear*.

B. This now explains the disease we sometimes see in those whose tears run down in a constant stream upon the outside of their faces.

T. Yes, and a very serious disease it is: the orifices are *closed up*. Many persons have submitted to the painful operation which is rarely successful, of having the outlet opened anew by artificial means. We see, therefore, the kind intention which provided the opening in the first instance. "It is easily perceived the eye must want moisture; but could the

want of the eye generate the gland which produces the tear, or bore the hole by which it is discharged, —a hole through a bone!"

Fig. 8.

a, the lachrymal gland, the source of the tears. *b*, the channels or ducts which lead the tears from the lachrymal gland into the eye. *c*, *c*, the puncta lachrymalia, or tear holes, which conduct the tears into the outlet or lachrymal sac, by which they are discharged into the nostril. It will here be noticed, that the *reservoir* precisely resembles the *eye*, not only as to having an outlet, but as to the fountain being in both cases elevated *above* the place of reception. Owing to this circumstance, the tears more readily enter the eye. It will also be observed, that in each instance the source is at one corner, and the outlet at the opposite. This is evidently beneficial to the eye; as hereby the tears must pass the entire length of the organ, and lubricate its whole surface, before they are discharged.

Are there any other respects in which we discover intentional contrivance for the security of the eye?

A. It is lodged in a strong, bony socket, called the orbit, composed of several bones, the upper of

which is arched and sustains a portion of the brain. In the back part of the socket, a large quantity of fat is deposited, on which the ball rests as upon a cushion, so as to enjoy easy motion in every direction; and it is because this cushion is apt to be wasted by disease, the eye usually appears sunk after a long sickness. The eyebrows are described by Socrates as a thatched pent house, to prevent the sweat and moisture from running down into the eye. The eyelashes are another additional protection.

B. What is most striking, there is such a number of these protections, the lid, the socket, the brows, the lashes, the tears, displaying an extraordinary degree of care and solicitude, proportionate to the importance and delicacy of the organ;—not one of which, moreover, as we can see, has the least tendency to produce another, and therein presenting the more evidence of design. But notwithstanding the perfection of this wonderful mechanism, has it not been said that there is a certain spot on the part where the image is formed which is insensible?

A. It is supposed to be the spot where the nerve enters the eye; but the manner in which the defect is remedied is a new proof of the wisdom with which our eyes are made. There is the same little blind spot, it is said, in both eyes. But it is stated, that if one eye should happen to be insensible, the same difficulty cannot occur in the other at the same time; or both spots cannot blind us at once; so that we shall never be conscious there is any such spot, when both eyes are open. The contrivance is this. The nerve,

which has to enter *somewhere* to make the retina on which the image is received, does not enter exactly at the centre, but a little towards the nose. Now, mathematicians say, that owing to this slight variation from the centre, it can be calculated to a demonstration, that the little circle or image in the eye, can never fall on both insensible parts at the same time. The experiment is easily tried. Place two small circles of white paper upon a dark colored wall, at the height of the eye, and at the distance of nearly two feet from each other. If the spectator, at a proper distance, shuts his right eye, and looks with the left directly at the paper on his right hand, he will not see the left hand paper, although the objects around it are visible. But let both eyes be opened, and it will appear distinctly.

Varieties of Eyes.

T. Are the eyes of all animals constructed alike?

A. The differences are very numerous and striking. Besides the evidence of design in the structure of the eye itself, we have a further proof of the existence of wisdom in its formation, and that it is no *blind* production of nature, when we observe that the sense of seeing is not given to all animals in the same way, but that the organs are varied as is best adapted to the different kinds of animals. The varieties extend to almost every part of the eye. *Fishes* have a re-

markable peculiarity in their eyes, which is required by the nature of the element they inhabit. It is a fact with respect to light, that whenever it passes directly from water into a magnifying glass, the glass must be more rounded, in order to produce the same effect as would take place, if the glass was surrounded by air. Agreeably, it is found, that the chief magnifier in the eyes of those animals which inhabit the water, is far more round than in those of land animals. The structure which produces the tears is wanting in fishes. The water in which they live renders the tears unnecessary. The eel, which has to work its way in the mud amid the hardest and roughest substances, is provided with a horny, transparent case for the eye, which protects the part without obstructing the vision. The frog has a similar security.

B. What, pray, can the frog want of a pair of spectacles?

T. To defend the eyes from the sharp edges of the spear-grass, &c., among which these little creatures have to live. But you may give the description.

A. As the progressive motion of this animal is not by walking but by leaping,—if his eyes were not provided with such a case, he must either shut them, and so leap blindfolded, or, by leaving them open, must run the risk of having the front part of the eye cut, pricked, or otherwise injured; but this membrane, like a kind of spectacle, covers the eye without taking away the sight; and, as soon as the occasion

ceases, the animal withdraws it into a little cell, where it rests till its use is again required.

B. A pair of goggles, and a pocket to keep them in! If this be not design, it would be difficult to say what would be so.

A. Many birds have a similar security. The eye of the mole, which has to work its way under ground, is singularly suited to the habits of this animal. Every thing about the construction of this little creature, seems to decide that it must dig the earth and live in the ground. The form of the feet, for example, is like that of so many shovels. Unless the eye, therefore, were adapted to such a mode of life, the situation of the animal would be truly unfortunate. This adaptation exists. "The eyes of this little pioneer are scarcely larger than the head of a pin, and are, besides, sunk down very deeply into the skull. To shelter them still farther, the eyebrows, if so they may be termed, not only cover the eyes, but present a considerably large prominence, or cushion to any sharp or protruding substance which might push against them. In short, the eye of a mole looks like a pin hole in a piece of velvet."

The eyes of animals which catch their food by night, such as the cat, owl, &c., possess a faculty not given to those of other species, viz., of closing the pupil entirely. By this means, they are able to favor their eyes in a bright sun, and avoid the glare which must needs be painful to such eyes as theirs, which have to be made very delicate and sensitive to see in the dark; besides, the glare must injure the delicacy

of the eye. Dr. Herschell, the celebrated astronomer, while pursuing his nicest observations, was in the habit, it is said, of practising upon this very principle; that is, of covering his eyes in the day, to increase the sharpness of his sight in the night.

It has been often noticed, that the pupil of a cat's eye, and that of several other animals, is not round, like our own,—but it is in the form of a long slit, reaching from the top to the bottom of the eye. It is made in two parts, like the sliding doors of a modern parlor, so as to admit of a close joint to exclude the daylight entirely; or, of being wholly drawn back, so as to leave no obstruction to the light, in the dark places the animal loves to frequent.

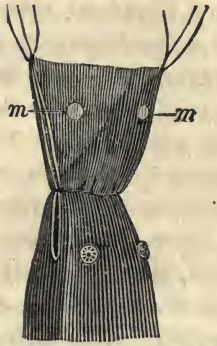
T. Is the number of eyes the same in all animals?

A. The fly, the bee, and various insects, have many eyes, or what is equivalent, set round on each side of the head, though they are so united, as to resemble only two eyes at the first inspection. It requires a microscope to see them, and the appearance is extremely beautiful. Some insects, it is computed, have as many as several thousand eyes.

T. What design of Providence do you here discover?

A. As these insects have no motion of the eye, they would labor under an evident disadvantage, unless their organ of vision was a kind of multiplying glass, looking in every quarter, and catching every object.

Fig. 9.



The head of an eel; the skin is represented as turned back.—*m*, *m*, the transparent horny coverings of the eyes, which being situated in the skin, are separated with it.

T. Upon a *review* of the construction and properties of the eye, what general reflection is suggested as to the proofs of intelligence and wisdom it exhibits?

A. That it embraces so many distinct and independent contrivances, not one of which has any tendency, as was observed, to produce another; that there is such a variety of provisions, dissimilar in their nature, and which nothing but design could have brought together; giving great complexity to the instrument, but each adding a distinct excellence. The greater the variety, and the more intricate the structure, the more evident the design. The eye *sees*, it may be said, and this is design enough. But because the eye sees, it does not follow, there should be so many provisions to enable it to see so perfectly;—

it does not follow, there should be a curious mechanism by which it can adjust its glasses, to enjoy the advantage of a microscope and a telescope at the same time;—it does not follow, there should be the contrivance of a perforated curtain, by which the quantity of light admitted or excluded is tempered to the delicate sensibility of the eye;—it does not follow, that the glasses should be of different substances, or so constructed as to contain the highest improvement of the modern telescope, in regard to preventing a certain rainbow appearance, which would obscure the sight;—it does not follow, there must be an increasing consistency of the principal glass, from the edge to the middle, remedying another inconvenience to which all the telescope glasses of the same form that ever were or can be made are unavoidably subject;—it does not follow, that the principal glass must also lessen its consistency from the centre to the sides, so as to agree and make, as it were, one substance with the glasses between which it is situated, thus avoiding another difficulty which in every other telescope, of a similar nature, is perfectly incurable;—it does not follow, that the nerve of the eye, which receives the image, should enter a little out of the centre towards the nose, so as to prevent any image from being lost in both eyes at the same time;—and, when we have a perfect eye, it does not follow, it should be so well protected, and preserved so constantly bright and fit for use; that it should be lodged in a bony cavern for its more perfect protection from all outward violence, with a soft, flexible veil hang-

ing before it, susceptible of the quickest motions, to be interposed upon every occasion,—and furnished with an exquisite contrivance to cleanse and moisten it, and a conduit to conduct off the liquid which has been employed; and even *then*, there is no natural consequence by which it follows, that it must be fitted with such a complete set of muscles to turn it in every direction, and give us the most perfect command over the organ.

T. After having examined the most wonderful instrument with which we are acquainted, and with which no work of human ingenuity admits of comparison, it is quite superfluous to extend our research to other parts of the animal structure, for any purpose of *religious* conviction. There is no occasion for multiplying examples of contrivance, to prove a *contriver*. The organ of hearing is more obscure in some parts of its construction; but as it exhibits a new description of philosophical principles, quite as admirably applied, you may give some account of this structure. What traces of a *Divine Intelligence* do you discover in the *ear*?

B. Before leaving the eye, there might have been remarked one design, more interesting, perhaps, than any which has been named.

T. And what may that be?

B. The pleasures and use of sight seem to be the most delightful proofs of a designing *Providence*, independent of any particular construction of the organ itself. Without this sense, a large part of our capacities would be lost to us. Our sensibility to the plea-

sures of vision, one of the most constant and exqui site we possess, would have been given us in vain. Not only so, our intellectual capacities would have been in a great measure useless; for how little could we know without the *eye!* In this view, the mere existence of this little telescope, without any reference to its structure, does of itself conduct our minds to an intelligent and beneficent Author. It forms the same evidence of design, as the artist exhibits, who, when he has made a machine, provides the spring, the pendulum, or the weight, which is necessary to put it in motion.

T. Very true; there can be no more decisive evidence of intention and wisdom, as to this wonderful organ, than that it is not only a most exquisite piece of workmanship in itself considered, but that when the instrument is made, it is perfectly adapted to our wants, and is necessary for the exercise and improvement of our noblest faculties.

B. The same thought is beautifully suggested by Addison. "Our sight is the most perfect and most delightful af all our senses; it fills the mind with the largest variety of *ideas*, converses with its object at the greatest distance, and continues the longest in action without being tired or satiated with its proper enjoyments."

T. Sturms, after giving a minute description of the eye, has expressed in his devout and animated manner, a reflection upon its uses, which is very pertinent in a *religious* view, and which you may quote.

A. "I praise thee, O Lord God, for having formed my eye in so wonderful a manner! I have not hitherto considered the gift of sight as I should have done, that is, as a masterpiece of thy hands, and as a convincing proof, that even the most minute parts of my body are the works of God and not of blind chance. Pardon me, O wise and Almighty Creator! if, while I have used my eyes, I have not thought of thee with the warmest gratitude. May I employ them in examining thy word and works; and whether I contemplate the heavens or the earth; myself or the sacred volume; may I be induced to bless and praise thy wonderful goodness. When I behold the miseries of many of my fellow-creatures, let not my eye refuse them tears, nor my heart be shut up to compassion; thus may I fulfil the views of thy goodness, and through Jesus Christ be worthy of thy approbation."

T. A similar reflection might with but too much propriety, be extended to all the powers with which our Creator has endowed us;—that we do not devote them, as we should do, to his service. I trust, that, in contemplating new proofs of his power and wisdom, we may be excited to a stronger disposition to honor him with "our bodies and spirits which are his."—You may proceed to the next description.

THE EAR.

A. Although the construction of the ear, anatomists observe, is not so well understood as that of the eye, it exhibits in its general form, both internal and external, a mechanism which is admirably contrived for the reception of sound. It is fitted with a fleshy rim on the outside, which is called the *concha*, or trumpet,—because it spreads like the mouth of a trumpet, around the hole of the ear where the sound enters the head; and the use of the trumpet is, to collect the sound into this passage. *Ear trumpets* are constructed upon this principle, for the benefit of persons who are hard of hearing;—only the spreading part is much larger than it is in the ear. The *artificial* invention shows the wisdom of the *natural* instrument, and how evidently it was designed with reference to the uses it answers in the animal structure. The risings and furrrows which give the rim of the ear such an irregular appearance are said to perfect the trumpet, by directing the sound more completely into the hole. In those persons who have not flattened their ears down upon their heads by tight bandages, but suffered the rim to take its natural position, it slightly inclines forward, like holding our hand back of the ear, when we wish to hear more distinctly. This has been mentioned as remarkably the case in savages, whose hearing is uncommonly delicate. Many animals, especially the little, timid, and helpless rabbit, have the trumpet much larger and more perfect than

in the human species; and are also capable of turning it to any quarter from which they may be anxious to collect the slightest sound. "This motion of the ear," says Richerand, "is lost, or more properly speaking, not employed in the human ear, as long as the organ continues in a perfect state; but when its more internal mechanism is injured, and ceases to act upon the sound as usual, the external ear resumes the office to which it was originally adapted, and by a degree of motion and erection assists the hearing." A little distance within the hole of the ear, we come first to a membrane stretching entirely across from side to side, forming a complete partition. It may be compared to the *pelt* or head of a drum; and is commonly called the drum of the ear; anatomists term it the *membrane of the tympanum*, which means, skin of a drum. Behind this partition, we come to an open space usually termed the barrel of the ear,—the anatomical expression is *tympanum*, from a Latin word signifying a drum. What is most curious to observe, is the little clock work within this barrel. It is a contrivance of four extremely minute bones, one of which is fastened by the end into the main drum head, that is, the membrane of the tympanum, and the others, connecting along from the opposite end of this bone, stretch up into the barrel of the ear, till the last stops upon another drum head, drawn over the mouth of another barrel, which is deeply situated in the solid bone of the skull, and which contains a *watery* matter, and also the *nerve of the ear*, floating in this liquid. The *second* barrel, so to term it, is called

the *labyrinth*, from its being so winding and full of passages. There are some other little internal cavities and passages; one especially leading into the main barrel with a membrane over it, called the *foramen rotundum*, or round opening; another, called the *Eustachian tube*. This is about the whole of the machinery.

B. There seems to be an abundance of it, but rather complicated and obscure.

A. The waves of the air, and what is called *sound*, is attributed to a certain peculiar motion in the air, resembling *waves*, produced by the sounding body, are supposed to enter the ear and strike upon the principal drum head, or membrane of the tympanum, like a drum-stick,—and to be communicated, by means of the little bones and the air on the inside to the other drum heads; these, in their turn, are presumed to operate upon the fluid contained in the barrels they cover, so as to affect the delicate filaments of the nerves which float about in this fluid—and thereby produce the sensation of hearing. It is one continued transmission through a complicated chain of conductors most mechanically fitted up for the purpose. The sound is also supposed to be carried to the nerve, in some degree, through the solid walls of the ear; just, as in a stick of timber, we can hear the slightest tap upon one end, by holding our ear to the other.

B. The little bones seem to be the most curious part of the contrivance.

A. To look upon, anatomists say, they are more like what we are accustomed to call machinery, than almost any thing beside in animal bodies. It is, as if, upon cutting open a drum, we should find a chain of little rods hinging one upon another across the whole length of the barrel from head to head. It has been suggested, that they probably tighten or loosen the drum heads, with which these bones communicate; just as the musician loosens or strains up the head of his drum by means of the cords and leathers, which we see on the outside. By stretching or loosening the head, he strengthens or weakens his sounds; and the little bones are supposed by many anatomists, to produce the same effect.

B. They make a *tuning* apparatus then, it seems, for our ears.

T. Their *chief* use is generally conceived to be, to conduct the sound from one drum head to the other. Do you know that every drum has a hole in the barrel? and are you acquainted with the reason?

B. It would seem necessary to admit the air into the drum; otherwise, the air would not be the same on both sides of the drum head, and whichever should press the most,—the external, or the internal air,—it would crowd against the skin and be injurious to the sound; at least, I suppose it is for some such reason, that the hole is made.

T. Why then are we not subject to some inconvenience in the ear, when the barrel has no communication with the air by means of the external ear, on account of the membrane of the tympanum, which

Fig. 10.

a, the external ear, called the concha, or trumpet. 10, hole of the ear, slit open; termed the meatus auditorius externus, or outward passage of the ear. 9, membrane of the tympanum, stretching across the ear; or the main drum head of the ear. It makes a complete partition at the bottom of the hole of the ear. 1, 2, 3, 4, lines pointing to the four little bones seen extending across the tympanum or drum, behind the membrane of the tympanum, the last of the bones being in the shape of a stirrup: and the lower end of the first bone being inserted into the membrane of the tympanum. 6, entrance into the labyrinth, or back drum of the ear, having a membrane over it on which the stirrup plays. 5, three lines pointing to the semicircular canals, which form a part of the labyrinth. 7, the cochlea or shell, so named from its resemblance to a cockle, and forming a portion of the labyrinth. 8, the Eustachian tube, leading from the tympanum or drum to the back part of the mouth.

you know extends across and shuts up the passage, a little within the entrance?

A. Though there is no communication in this direction, there is another passage, called the *Eusta-*

chian tube, which is a slender pipe sufficient to conduct the air, and which leads from the inside of the barrel to the back part of the mouth.

B. How wonderful to notice the many particulars wherein our own ingenuity has been anticipated in the contrivances of nature!

T. Do we discover any provision in the structure of the ear, to guard against the dangers to which it is exposed?

A. The hairs which are placed at its entrance, together with the *cerumen* or wax within the cavity, prevent the introduction of foreign bodies, such, for example, as grains of sand, dust, insects, &c.

B. Then it must be cruel to remove this hair, as is practised upon some dumb creatures.

T. I presume you speak of the *horse*. The loss of this protection no doubt occasions much suffering to the poor animal. He has no means, like ourselves, of removing obstructions from the ear; and therefore should not be deprived of any natural security.

B. I do not see but that the organ of hearing is as admirably contrived as the eye, notwithstanding it is said to be so obscure. Perhaps we may still say of this organ, however, as of the eye, that the most striking demonstration of a designing intelligence is its relation and necessity to our other faculties. "It enables us to hold communion with our fellow creatures, to inspire and exalt our understandings, by the mutual interchange of ideas, and thus to increase the circle not only of our physical but our moral relations.

The charms of eloquence, the pleasure resulting from the concord of sweet sounds, are other sources of intellectual enjoyment, which contribute to place this sense among the most delightful as well as the most important we possess. Whoever has witnessed and attentively observed the distressing effects arising from a loss or diminution of its sensibility will readily acknowledge that such deprivation throws us at a distance from our fellow-creatures and in the present state of society renders us more solitary beings, than the loss of sight itself." One would therefore say, the first manifestation of Providence in this admirable organ relates to its importance.

T. No doubt, an All-wise Creator principally appears in such views of the subject as these. We are to be most grateful for the uses and enjoyments for which every part is fitted, rather than for the skill displayed in the construction of the part itself. These considerations should again induce us to adore the ineffable wisdom and wonderful goodness which our maker displays in every part of our frame. They should make us more sensible of the value of the organ by which we are enabled to enjoy the benefits of speech, and to receive the various delightful impressions which are imparted by sound. While we reflect how much our happiness would be diminished, if we could not communicate our thoughts by conversation; how lamentable we should feel it, if we were to be denied this medium of intercourse with our friends; it should teach us to value our own

blessings, and to praise God who among his innumerable benefits has given us the power of hearing. There is now another field we are to survey, which will bring into view new occasions for admiration. The head contains the organs by which the body is directed. We are to see the machinery by which the motions are performed; that is, the bones and muscles generally, which are the active parts of the body. You may describe the principal and most important bone,—the one immediately connected with the head.

THE SPINE.

A. The head rests upon a strong, upright, bony column, which forms the centre of the back, and is called the *spine*, or *back-bone*.

B. I never could conceive why this should be called a bone. We certainly bend it very easily, and therefore it cannot be one continued, solid body, like a bone.

T. It is a *chain* of joints of very admirable construction, and this you will see.

A. Anatomists describe it as a wonderful specimen of mechanism. It has to answer several important purposes most difficult to be united. A portion of the most delicate substance of the brain, called the *spinal marrow*, is continued down through the hol-

low of this bone, resembling the pith in the stalk of a plant. This substance is so exceedingly tender, and vital, that the slightest wound, or even pressure, would be productive of serious and probably fatal consequences. It might seem, therefore, that in order to secure it the more completely from any injury, the case which contains it ought to be a firm and *unbending* tube. Yet the spine *must bend* to admit of the motions of the body. Any considerable bending in one particular spot, however, would press upon the marrow within, and be highly dangerous.

The danger is happily avoided by the bone being composed of a great number of little rings piled one upon another, as many as twenty-four, which are called the *vertebræ*, from a Latin word, which signifies to *turn*. They admit of a great flexure through the whole, without requiring each to bend but a very little. Thus, stooping is not a sudden, hinge-like motion in a single spot, like shutting a penknife; but is the united bending or curvature of several bones, for a considerable extent upon the back, like bending a piece of whale-bone. If the bend were entirely at one place, a wrinkle or crease would be made in the spinal marrow, such as we may see on the inside of the joint of the finger, when we bend the finger inward. No other bone in the body is so constructed. No other requires it.

B. By no other requiring it, is meant, no doubt, that no other bone which has to bend, contains the same delicate contents. This is truly a wonderful expression of design. The only bone in the body

which bends with an elastic curve instead of a hinge, is the only one where a hinge would be dangerous. Every one knows that his back is composed of little bones; but few, probably, are aware how much wisdom it exhibits, and that their lives would have been in danger every moment, upon any other construction. Still, it would seem that a bone composed of so many little rings, must be very liable to be slipped apart, especially, when we consider what violent motions we sometimes have occasion to make with it.

T. Do we discover any evidence of intentional precaution against this accident?

A. We behold a wonderful structure, having an immediate respect to this very danger. The bone is as skillfully secured, as the substance entrusted to it is vital and tender. It is as *safe*, as we might suppose it *dangerous*. Notwithstanding all the sudden and violent motions to which this part is subject, there is no injury to the body perhaps which is more infrequent than disuniting or displacing any of the bones of the spine. Although the bones are in such constant motion upon one another, the *hollows* of the rings perfectly agree; so that the hole in one bone corresponds exactly with the holes in the two bones contiguous to it—else it would produce a break in the spinal marrow. They always form one close, uninterrupted channel. Bend the spine as we please, practise all the contortions upon it we can, not one of the little bones can be made to project upon the interior cavity, so as to injure the smoothness of the bore. Let an artist be requested to execute a similar piece of work. Bespeak a hollow cane of twenty-four

joints, to be used for the ordinary purposes of such an instrument, and yet to inclose a most tender substance, exceedingly precious, to which it would be fatal if a wrinkle should be produced in it at any one of the flexures. No mechanic could probably be induced to undertake so difficult a task.

T. And how is it done in the spine?

A. The first contrivance is a firm bandage from ring to ring. Besides this, there is a further security; and a more studied security,—one more carefully contrived, or more evidently evincing care, it is impossible to imagine. The bones are not smooth and regular: on each of them there are what anatomists term *processes*—projections or *spurs*, which give them, at first view, quite a deformed appearance, and such as we see in no other bone in the body. Every one of these protuberances, or processes upon the bone, is found, upon examination, to be a check to some improper motion. Whatever slip attempts to take place, it is supported by the form of the bone. It is past the ingenuity of man to dislocate the spine: that is to say, to find a mode by which he can elude the wisdom of the construction; in which, by any pressure short of breaking the parts, he can thrust one of the bones from between its neighbors. "Let him take, for example, into his hands, a piece of the clean picked bone of a hare's back; consisting, we will suppose, of three vertebræ. He will find the middle bone of the three so implicated, by means of its projections, or processes, with the bone on each side of it, that no pressure which

he can use, will force it out of its place between them. It will give way neither forward, nor backward, nor on either side."

T. And what is most impressive, here, we have a structure which cannot be interpreted as a *natural* effect. The processes of the spine are not naturally produced by any motions—but they are checks to *hinder* motion. When we endeavor to bend backward too far—the tendency of this endeavor would be to smooth away the joint, and suffer the motion to be made: it would be any thing but that of forcing out little *spurs* to prevent it.

This admirable structure, therefore, has but one conceivable explanation,—that of an *original design.* We observe securities introduced, where the natural result would have been the very opposite. We see the reverse of a natural cause. We see design, and that is all we perceive. Truly may we say, how evident the indications of his agency, whose *fingers have fashioned us*, and in whom *we live, and move, and have our being.*

But you will not overlook another curiosity in this wonderful part—the provision for turning the head.

A. The plan of the spine, upon which the head is supported, forbids the turning of one bone upon another. Its joints are hinges, confining to one motion, that of stooping and bending merely. We cannot turn our breasts opposite to our feet. We see the wisdom of this, if only on one account,—the safety of the spinal marrow, which ought evidently to be spared every unnecessary motion. This is the principle of the spine through an extended series of

more than twenty bones. But one exception was necessary to enable the head to turn, by a motion of its own, without always being at the trouble of turning the whole body. To admit of this, one solitary deviation is introduced. One bone of the neck, which is a part of the spine, is permitted to turn round,—and only one. The construction is this. The head, together with the first bone of the neck, forms a perfect swivel, like the head of a cane, made to twirl round upon the staff. There is a notch in the first bone which receives a pin that runs up into it from the second, making what mechanics would call a *pin*, or *pivot joint*. Upon this joint the head has a firm and accurate motion within a certain extent on each side, as far as is necessary.

B. Every part seems to be the most wonderful, till we hear another described. Still, one might almost tremble to think of *turning* the neck, after what anatomists say of the spinal marrow.

T. It is this which renders the mechanism truly remarkable. There was plainly a choice of joints to enable the head to turn. Now, anatomists invite our attention to the singular safety of the joint by which this motion is performed.

A. There are several joints which would have permitted it. The bone which revolves might have been fitted with a cavity to the head of the bone immediately beneath. There are a number of these joints in the body. They are called *ball and socket* joints, in which the head of one bone is received into a cup or socket in the other. There is such a joint

in the *neighborhood* of the neck, at the shoulder blade; and no other kind is ever employed in the body, for a revolving joint, except in the single instance of the neck. They are all liable, however, to *slip* in some degree, in the socket; which, while of no importance in any other situation, would have been dangerous to the spinal marrow. A smart blow might easily dislocate such a joint. But nothing can slip a *pin joint*, short of breaking the pin.

B. I do not see how any atheist could ever have been acquainted with his own structure.

T. Do you think of any striking resemblance to the works of art, in the mechanism of the neck?

A. When we bend the head downward, we make use of the *hinge* joint, which is situated between the head and the first vertebra of the neck. In moving the head horizontally, that is, in turning it round on either side, we make use of the *pin* joint, which lies immediately under the former, and plays between the first bone of the neck and the second. The same two kinds of joints, similarly situated, and exactly resembling those of the human head, are employed in the frame or mounting of a telescope. It is occasionally requisite to move the telescope up and down, as when we want to point it to a star which lies higher or lower than another. It is also required, that it should be able to take a circular motion, as when we want to remove it from one star and point it to another star, by the side of it. For the first motion, there is a hinge upon which the telescope plays up and down; for the next, there is an axis or pivot on which the hinge and the telescope upon it turn round together. This is

precisely the mechanism which is used in the motions of the head!

T. You can turn the telescope, however, entirely round; but you are aware, it is not the same with the head. The head has only a certain degree of motion from side to side; and this is confined to a very small compass, though sufficient for the purpose;—sufficient, that is, with the motion of the eyes, which nearly completes the circle. But for this limitation of the motion, I need not tell you the spinal marrow would have been in danger of being twisted or compressed. A most artificial contrivance is introduced, which prevents this danger—can you describe it?

A. There are two ligaments, small, but exceedingly strong, which are attached to the joint in such a manner, as to allow it sufficient play, but not to admit of any motion beyond a certain extent. They are called the *moderator ligaments*, from a Latin word signifying to moderate or check.

B. Then, if I understand it, when we attempt to turn the head upon either side farther than would be safe, one of these cords immediately arrests the motion, like a *check rope*, such as we sometimes see employed on gates, doors, &c., and acting exactly upon the same principle.

T. But there is another circumstance which it belongs to our present purpose to understand. You have seen that the structure of the skull is admirably adapted to preserve the *brain* from being jarred. Is there any harmony of provision for the same purpose, in the structure of the spine, that is, of the support on which the brain immediately rests?

A. Between all the twenty-four bones of the spine there are *springs* introduced, of a substance resembling gum elastic or Indian rubber. They are cartilages or gristles; and may be seen to perfection in a loin of veal. They operate between the vertebræ as so many *spring cushions*, so that, when we jump or light heavily upon the ground, the violence of the blow is in some measure broken by the spring, and the jar is diminished upon the brain. "We can readily understand," says Dr. Bell, "how great the influence of these twenty-four joinings must be in giving elasticity to the whole column; and how much this tends to the protection of the brain. Were it not for this interposition of elastic material, every motion of the body would produce a jar to the delicate texture of the brain, and we should suffer almost as much in alighting on our *feet*, as in falling on our *head*."

But there is another very curious provision for the protection of the brain; the *curved* form of the spine, which resembles an italic *f*. Elastic as this bone is, yet if it were perfectly *straight*, a jar would have extended through it to the head with much more power. Thus, if we should place a ball upon the end of a long, straight spring of steel or whale-bone, and strike the other end upon the ground, the ball would probably be shaken off by the concussion of the blow. But if we first *bend* the spring in the shape of the letter *f*, we should see the ball would not be jarred, but would have an easy motion, like a bird rising and falling upon a bending branch. Thus admirably calculated is

the spine to carry the head without a jar or injury of any kind.

Fig. 11.

The *human spine*, so named from a Latin word signifying thorn, on account of the sharp processes, *s*, *s*, *s*, which project from the bones, and form the outer ridge of the back. *a*, *a*, *a*, the cartilages, or plates of gristle, inserted between all the vertebræ. It will be seen that in bending backward, the processes will touch and prevent the motion; also, that the strongest processes are in the lowest division of the spine, where the loins are situated, and where the motions of the back are greatest. In the middle portion, between the vertebræ *B*, *B*, it will be observed that the processes are almost in contact with one another; so that in this part the spine hardly admits of any flexure. The ribs enclosing the heart, lungs, &c., are attached to this portion of the spine, and consequently, any considerable bending would here be unsafe. In the upper division, the processes are again spread; this being required for the flexibility of the neck.

T. Is this wonderful mechanism the same in all animals?

A. In quadrupeds the number of the vertebræ is from thirty to fifty. In the common serpent it is about three hundred. In the shark the number is somewhat upwards of two hundred. In the eel it exceeds an hundred; while in common fish it is nearly the same as in quadrupeds. Nor is this all with respect to the serpent. Not only is the flexibility of the back increased by the multiplicity of the joints, but the manner in which the vertebræ are united is truly remarkable. They are not united by surfaces which are nearly smooth, as in the spine of a quadruped, nor is their flexion impeded in any direction by any projections of the bone. They play freely into one-another like a cup and ball. One extremity is rounded and received into a corresponding cavity in the contiguous vertebra. At the other extremity the arrangement is reversed. Here is a cavity which receives the point of the next bone. So that the whole spine is a continued chain of ball and socket joints, affording a free motion on every side. As a piece of mechanism for pliancy and flexibility, without too much sacrificing a secure union of the joints, it is as palpable a contrivance as a watch-chain, which it does not a little resemble.

B. This explains why these nimble creatures are able to twist themselves into so many forms.

T. Yes; but the more interesting explanation is, it affords them a compensation for their want of feet. Having no feet they need this structure of the spine.

B. I perceive it. As they have to make all their motions with their bodies, if their backs were not as jointed and flexible as possible, they would not be able to move; at least, not with any facility.

T. Do you see any *natural* cause why the want of feet should have given them an unusual number of bones in their backs?

B. I see no cause but design.

A. The vertebræ of the *fish* differs from that of the serpent in there being a cavity at *each* end. Every joint resembles two *cups* united together by their edges, so as to leave a hollow inclosed space. This space is filled with a gristly substance less solid than bone. One design may be to diminish the weight of the spine, and render the fish thereby more buoyant in the water.

The neck joints of the bird are remarkable. It is a structure by which the animal is assisted in smoothing and adjusting its feathers, turning its head backward under the wing, and thrusting out or drawing in its beak with rapidity in collecting its food. In the first place, the vertebræ are not united by flat surfaces, as in quadrupeds. They are rounded at the point of contact, so as to roll upon one another with more ease, and be capable of more flexion. Secondly, the upper joints of the neck can only bend *forward*, and the under ones admit only of a *backward* motion. The consequence is, there are two curvatures in opposite directions, like the letter S, so that by spreading or contracting them at the same time the neck is lengthened

or shortened much more expeditiously. The elegant form of the swan's neck is owing to this construction. But there is more to be noticed. The vertebræ of the back are as remarkable for the rigidity of the joints, as those of the neck for their uncommon flexibility. The bird wants a solid support in the back, to sustain the motions of the wings in flying. Had this portion of the spine been as flexible as in other animals, the body would have been liable to be bent or twisted round. The more unwieldly birds which do not fly, are said to be without this construction.

B. This is the more remarkable, because it seems to be the very reverse of a natural effect. The *natural* tendency of the exercise of the wings, I should suppose, would be to *bend* the joints of the back and not to *stiffen* them.

A. In general the length of the neck is such, that, added to the head, the length of both is equal to the height of the animals' shoulders from the ground. In some fowls it greatly exceeds this proportion. This is necessary to enable them to seek their food below the surface of the water in which they swim. The same proportion is equally remarkable in quadrupeds; otherwise they could not easily reach the herbs on which they feed, or the water they drink. Among all those in which this rule is observed, the size of the head is less in proportion as the length of the neck is greater. But for this circumstance, the animal would be put to great exertion in raising up his head. This rule, however, is not observed with regard to animals

that have means for raising their food without extending their necks,—such, for example, as man, the elephant, &c.

THE BONES.

T. We might now pass to some other views of this masterpiece of divine wisdom and power, besides those which invite our attention in the *solid* parts of the animal structure. But I will detain you a little longer. If the bones and joints have been called the coarsest parts of nature's workmanship,—still they are more easy to be understood, because they more nearly resemble the kind of mechanism to which we are accustomed: we can compare them with works of art;—and therefore, they are the properest to be alleged as proofs and specimens of design. There is one remarkable variety in the bones, which challenges our admiration as an evidence of original purpose and wisdom: a portion of them are *hollow;* and it is wonderful to observe the skill displayed in the selection; and the acquaintance exhibited with mechanical principles.

A. The bones of the limbs belong to this class.—We may notice the tubular construction in the wing or leg bones of a bird. Mathematicians demonstrate, that in any instrument requiring strength, size, and the

greatest possible lightness at the same time, as in the limb bones, for example, the hollow form is the best. Every boy is sensible of the superior strength of a cane pole beyond that of any other rod of the same weight. The reason is, it is hollow. If he should split the cane into strips, and glue the strips together ever so strongly, but without leaving any hollow, though he would have the same *wood*, he would find the rod hardly capable of supporting its own weight. A tin tube has very considerable strength; but flattened together, that is, no hollow remaining, it bends with ease. We see, therefore, it was not accident, but the skill of a wise *Mechanician* which has assigned the tubular form to the bones of the limbs, in which strength and lightness are particularly needed. What is more remarkable, this form is the most conspicuous in the bones of the *bird*. These animals have the most occasion, plainly, for light bones. Their bones, that is, the hollow bones, differ in three properties. First, the hollows are much larger in proportion to the weight of the bone than in those of men or of four footed animals. Secondly, these hollows are empty, or contain only air. They have a direct communication also with the lungs; the air which is received into the lungs, escaping and returning alternately by a hole in some of the bones; whereas, in man, &c., they are filled with marrow. Thirdly, the shell is of a firmer texture than is the substance of other bones; and therefore, less bone is required to furnish the same degree of strength.

Why this peculiar advantage bestowed upon the bird? It could only proceed from a designing intelligence. We see nothing in the nature or habits of *this* animal in particular to furnish him with bones more hollow or more empty than those of other species. And again, what *natural* tendency, which we can imagine, has a bone of unusual lightness to cover itself with feathers? One is *suited* to the other; but what effect had one to *produce* the other? Remarkably hollow bones might naturally enough have occasioned a remarkably nimble animal; but how could it have given him wings? We see a connexion of design, and that is all we perceive.

T. There are nerves and blood-vessels, which enter through the sides of the bones. Just for the purpose of shewing the wonderful attention which is paid to the most minute particulars where utility is concerned, can you mention what anatomists observe as to the direction in which the channels are bored for this purpose?

T. The holes are generally winding: they take a zig-zag course, so that they are nowhere in a single line directly across, which would most have weakened the bone.

B. We often find trees perforated by worms in this serpentine manner; and *Providence* has, perhaps, so directed the instinct of these little creatures for the same object.

A. In all the two hundred and sixty bones in the human body there is not one, but what is suited to its

place, or that would do, in any other place. Change the situation, proportion, dimensions, shape, of any bone,—and we can see at once, we violate some mechanical principle. Yet the bones are *original*, fixed parts. They do not take their form from our motions. They do not *wear* into the right configuration. The limbs of the infant are as perfect as those of the adult. They exhibit examples of almost every kind of mechanical power of which their nature admits; and whatever be the instance, anatomists observe, it is invariably the simplest, the most beautiful, and the least subject to derangement, which would have answered the purpose.

The manner in which the bones are articulated, or jointed, affords evidences of contrivance and contriving wisdom still more striking if possible, than those we discover in the configuration and proportions of the bones themselves. There is nothing perhaps in the whole frame a mechanic would be more likely to notice. The greatest curiosity and wonder to him would probably be the appearance of *selection*, that is to say, the employment of *chosen* joints in the different limbs, and the admirable *adaptation* of each to the particular motion required, as well as to the particular dangers of injury in the situation in which it is used. Every child knows that the bones are jointed; but he is not probably aware that no two joints are exactly alike, except in corresponding parts of the frame. We have the ball and socket joint, the pin or pivot joint, the hinge joint, and as perfect in every respect as could be produced from a cabinet maker's shop. One or

other prevails as may be best adapted to the motion which is wanted. Thus, a *hinge* joint admits only of a backward and forward motion. We have this joint in our fingers, enabling us to open and close them—which is all the motion that would be of any use. It would have been of no conceivable advantage to have turned the joints of the fingers completely round, so as to bring the nails upon the inside. At the shoulder, on the contrary, we want a joint which will permit us to stretch and expand the arm in every direction: there we have a *ball and socket* joint; where the round head of the bone is received into a cup, which gives it a free play on every side. At the neck, a joint is necessary that will suffer the head to revolve, but the spinal marrow requires that the joint should be subject to no slip, and that no loose motion should be allowed it, which, in the common ball and socket joint, it is difficult to avoid. Here we have a *pivot* joint,—a joint with a firm pin running up and accurately fitted into a cavity which allows the motion demanded, but permits no irregularity. Sometimes the same bone is constructed at the opposite ends for different species of joints where different kinds of motions happen to be necessary.—Thus, the extremity of the thigh bone is made for a ball and socket joint, where it is united at the hip, but for a hinge joint, where it is united at the knee. The utility is obvious. A hinge joint at the upper end would have permitted a backward and forward motion, but no other; and not a step could have been taken beyond a certain width, except by spreading

the limbs at the knee to a most awkward and uncomfortable angle. Again, had the ball and socket been placed at the knee, it would have been less firm than the hinge joint ;—" and there would have been no use that we know of, in being able to turn the calves of our legs before."

The bones are all *cased over* at the joints with firm, leathern-like caps, resembling the rings which artists employ to prevent the joints of their machinery from wearing away. The substance is gristle, and it is found in no other part of the bones, but at the joints. Besides this, there is around every joint a little bag which passes from bone to bone, containing a liquid, anatomists call it the synovia, which keeps the surface smooth, and is exactly the same, in effect, with the oil which mechanics employ for a similar purpose. The joints, in short, are both *leathered* and *oiled.*

This fluid is vulgarly called joint-oil, but it has no property of oil. It is more like mucilage, smooth and slippery to the touch; and therefore better adapted, than any oil to lubricate the interior of the joints and prevent ill effects from friction. It is regularly supplied by means of a membrane in the joint furnished with little glands, which pour it out as it is wanted. " A late improvement,' observes Dr. Paley, ' in what are called friction wheels, which consists of a mechanism so ordered, as to be regularly dropping oil into a box, which encloses the axis, the nave, and certain balls upon which the nave revolves, may be said, in some sort, to represent the contrivance in the animal joint; with this superiority, however, on the part of

the joints, viz. that here, the oil is not only dropped but *made.*"

T. This is not the only superiority of the natural contrivance. The more the joints are used, the more abundantly is the oil supplied. It would be thought a wonderful invention, if a wheel should be so made as to supply more oil to the axis, in case the traveller should see fit to accelerate his speed, or to take up a companion. But this is done in our joints; that is, the lubricating fluid is poured out in increased quantities when the joint is in use, and in proportion to its use.

B. What an exquisite provision! This will account for the uneasy sensation we experience in moving our limbs, after neglecting exercise for a considerable time. The oil is deficient.

T. A trifling item in the catalogue of evils we bring upon ourselves by indolent habits. Let me ask you what mode of *fastening* a joint you should suppose would be the most safe?

B. I know of none so firm as what mechanics always employ,—a *bolt.*

T. So, it is probable, a *mechanic* would say; but an anatomist would tell him that this would not have answered in the animal structure, and is never employed. A strong band of gristle about the heads of the bones is the fastening made use of; and it forms almost the only instance in which nature has departed from our mechanical expedients.

B. The advantage, I now perceive, is very plain, though it did not occur to me. Had the joints been

secured by a solid pivot, or any thing absolutely inflexible, the limbs would be more endangered. In extreme accidents the gristle will yield, and permit the limb to slip, without breaking the bone. All the remedy required is a smart extension of the cords; whereas, if a bolt would have been more secure, the difficulty is, it would have been *too* secure; since it is often the case that, if the joint did not give way, the bone must.

A. "In considering the joints,' observes Dr Paley, 'there is nothing which ought to move our gratitude more than the reflection, *how well they wear.* A limb shall swing upon its hinge, or play in its socket, many hundred times in an hour for sixty years together, without diminution of its agility; which is a long time for any thing to last; for any thing so much worked and exercised as the joints are."

T. Are there any remarkable varieties in the joints of different animals?

A. There are fishes which have joints of which the skeleton of man and animals generally furnish no examples. They are to be seen in the *fin.* The general structure of the fin resembles a fan, being composed of spines, or long slender bones, with a membrane between them, which when raised from the body and spread out, answers the purpose of a *paddle,* and sometimes of a *weapon* of attack or defence. When employed for the latter purpose it evidently requires as much firmness as possible. In the *pectoral fin* of some fishes there is a curious provision by which this object is effected. A mechanic might be challenged

to invent a more simple and beautiful contrivance. The first spine of the fin, the first stick of the fan, has a moveable bone in the shape of a ring attached to the lower extremity, which plays upon another bone that is immoveable. The ring bone has a hook, and it is in the power of the animal, by turning the bone round, to fasten the hook into a particular hole in the immoveable bone. In this manner the fin becomes so securely fixed that it cannot be moved except by a motion directly contrary to that which hooked it to the other. Any attempt to brush down the fin without regularly unlocking it is ineffectual. It is thus the *siluri* and the *gasterostei* give firmness to their fins when they wish to employ them as weapons of defence or assault.

T. You may describe some of the principal bones, besides those which have been mentioned.

THE ARM.

A. The *arm* is a remarkable piece of mechanism.

The *situation* of the arm upon the body is best accommodated to the uses of the limb, as every one will realize by imagining a different position.

By being *jointed* it is capable of a much greater variety of motions, than though it had been a single bone. Without a hinge in the middle, it would have been unmanageable; with a multitude of joints it would have wanted strength. It consists of three bones; one above the elbow, called the *humerus;* the other two between the elbow and the wrist. Of the last, the one which is in a line with the thumb is termed the *radius*—the other, the *ulna.*

T. What is the wisdom of this mechanism? Why *one* bone for the upper, and *two* for the lower arm?—Why is there not the same number of bones in both parts of the arm?

A. It would be difficult to imagine a more striking instance of mechanical ingenuity than we have in the double bone of the lower arm. One of the bones, (the ulna), makes a hinge at the elbow, and permits the arm to bend. The other has no concern in the hinge: it barely touches at the elbow, and may be said to be *loose*. But this arrangement is exactly the opposite at the wrist. Here the bone which is hinged at the elbow is only permitted to touch; and that, on the contrary, which touches at the elbow is united to the hand by a hinge. When we want to bend the arm, we use one hinge; and when to perform the same motion at the wrist, we employ the other. Had these two motions been performed upon one and the same bone, with a hinge at each extremity, the hand could have swung backward and forward,—but it could not have *revolved;* we could not have turned the palm of the hand upward or downward. For there can be no turning round, it is evident, upon a hinge joint. If the hand must turn, the bone must turn also to which it is hinged on; and must therefore be *loose* at the elbow, aud the elbow hinge must be assigned to another bone. Such is the contrivance actually adopted!

B. Any one might think how happy it is that we are furnished with a *double* bone in a part we use so much, so as to keep it more firm and steady under the

great pressures for which we have occasion at the wrist and elbow; but few are probably aware how ingenious it is, and how necessary to enable us to perform one of the most simple motions of the hand. Here is an example of creative skill which is always before us. Truly may we say, that to be convinced of the hand of God, we have only to look upon our own.

T. But you have not finished the description of this remarkable workmanship.

A. The construction adopted gives the benefit of a *long shaft* to the hand running as high as the elbow. This supports the joint when we turn the hand with a strong twist, much more than if the hand had been set to the wrist by a simple socket. If we grasp the arm a little above the wrist, when we roll the hand we shall feel the shaft bone revolving. A *mechanic* would understand the ingenuity of this structure; as an improved instrument, for screwing and wrenching, has recently been invented in almost exact imitation of the human wrist. It is obvious that the muscles which roll the hand are applied to much greater effect by means of this contrivance; for we find upon examination, a part is attached along upon the upper extremity of the shaft,—just as in using a pair of pincers, we always apply our strength at the ends of the handles.

It may here be mentioned, that the monkey has one more bone in the wrist than is found in the human species.

THE UPPER ARM.

The *upper arm* displays a different kind of mechanism. It makes a *hinge* at the elbow, permitting the

Fig. 12.

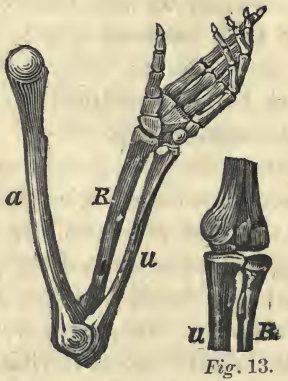


Fig. 13.

Figure 12.

a, the *humerus*, or bone of the upper arm, exhibiting the ball or rounded head at the top, which is received into a socket at the shoulder, forming an universal joint. *R*, the *radius*, or bone which turns with the hand, and is hinged at the wrist. *u*, the *ulna*, which is hinged at the elbow, and by which we perform all the motions of bending or extending the arm.

Figure 13.

A small portion of the humerus, and also of the radius and ulna, exhibiting the structure of the elbow joint. *R*, being the radius which is loose from the joint, for the purpose of enabling the hand, which is hinged at the opposite extremity, to revolve.

arm to bend: but at the shoulder we have what is called a ball and socket joint; that is, a *universal* joint, which will turn in every direction. If we

double one hand into the shape of a ball, and turn it round in the other, this would resemble the joint at the upper extremity of the arm. Now, the hinge joint, we can see, does well at the elbow; but at the shoulder, it would have deprived us of half the use of our arms. It must have kept them always at the same distance from the body; they would have swung forever in one particular line, like the arms of a loom.

The provision for uniting the arm to the body is in some material respects a very remarkable structure. It can only be appreciated, as it deserves, by one who will be at the pains to reflect upon all the possible modes in which the object *could* be effected—in which the arm could be attached by a firm and substantial joint. The ribs are evidently too slender and weak to sustain a great pressure at a single point no larger than the head of the arm bone. The arm, therefore, could not be jointed to a *rib*. It would have been forced into the body by the first violent effort. The *spine* would have been still more endangered. But no other bone remains in that neighborhood, belonging to the united frame of the trunk; the collar bone and breast bone excepted, which are evidently out of the question. We have here an obvious difficulty, and it is wonderful to see how it has been surmounted. A broad, flat bone, called the *scapula* or shoulder-blade, is spread outside a *number of ribs together*, against which the arm rests, and to which it is attached—and whereby the pressure is so much *extended* as to occasion no danger to the

frail materials underneath. A mechanic would say, there is a *cleet* put in between the *shore* and the building to save the building from injury. It is loosely bedded in the flesh; and is itself capable of motion. This perfects the provision. As the *shore* inclines to either side, the *cleet* shifts likewise, so as to keep the bearing, as nearly as possible, always equally true.

Fig. 14.

s, the *scapula*, or shoulder blade.

B. What a perfect piece of artificial contrivance! Truly, there is no end to the skill exhibited in the formation of the human frame. We have constant occasion to exclaim, how fearfully and wonderfully are we made!

T. And nothing more disposes us to this devout admiration than perceiving some *new* occasion for it, which is one of the great advantages of the subject we are now pursuing.

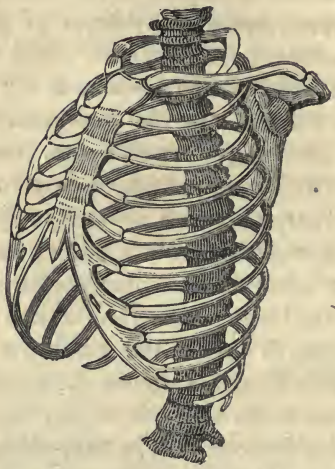
THE RIBS.

The *rib* bones are a far more curious and surprising structure than most persons are aware.

A. Besides protecting the heart and the lungs, and this use alone, in respect to the *heart* especially, would have been sufficient evidence of design, they are made to render another service which a hasty observer would hardly have suspected. The play of the lungs is referrible to the arrangement, of these bones. As breathing is nothing more than the rising and falling of the lungs, which operate like a pair of bellows, a contrivance was wanted to perform this mechanical operation. We mark in the provision adopted, the admirable simplicity,—as a mechanic would say, *the happy thought*, of the expedient. The contrivance is this. The rib bones are united to the spine in a direction sloping downwards. Being firmly attached at the ends where they are set on, the consequence of their sloping is, that when they come to rise, the muscles which pull them up necessarily draw them out, upon the principle of an umbrella. The cavity of the chest is consequently enlarged, and the lungs are permitted to fill, as the air rushes into the bellows when they are extended. Again, by sinking down into their former position, the cavity is diminished and the breath is forced out.

B. One cannot but reflect with admiration upon how slight a piece of mechanism our lives are depending; that is to say, upon the right choice of so simple a circumstance, as whether the ribs in their natural position, should pass directly around the chest, as most persons, it is likely, have never observed but that they do; or should have a slight degree of inclination downwards.

Fig. 15.



The *spine*, *ribs* and *breast bone*, or *sternum*, which constitute the frame work of the chest or thorax. Referring, however, to the plate, or to nature, we observe, that the ribs are not continued throughout from the spine to the sternum, but they are eked out and joined to the breast bone by means of pieces of gristle of a form corresponding to that of the ribs,—being as it were a completion of the arch of the rib by a substance more adapted to yield in every shock or motion of the body. A severe blow upon the ribs does not break them, because their extremities are tipped with this elastic or springy substance, which recoils and yields to the violence. It will also be noticed how much the same construction must assist the play of the chest in the operation of breathing. The muscles of respiration enlarge the capacity of the chest by elevating the ribs; and during the momentary interval of muscular action, the gristly parts of the ribs, from their great elasticity, restore them to their former position.

T. This is stating the case a little too strongly, though I am sensible of an admirable author you may have so understood. It was not, I presume, his intention to suggest, there could have been no enlargement and contraction of the chest, if the ribs, in their natural position, had passed directly around the body. But then this is certain, the motion in this case, must have been very considerable in the ribs to have produced any effect; whereas a slight rising from a *sloping* position changes the cavity of the chest immediately.

B. This is very plain. We can see it exemplified by placing our hands against our sides with the fingers touching in front, so as to resemble ribs. If they pass directly across, a slight motion does not change their distance from the breast; and if they were the real ribs, this motion would not effect any change in the capacity of the chest: but, if we first slope them downwards, we find a trivial rising extends them instantly from the body.

T. There is other mechanism beside the ribs concerned in the action of breathing or respiration; especially the rising and falling of the diaphragm, which is a muscle that separates the chest from the cavity beneath. And the wisdom of this is the more observable, as the ribs are liable to lose their elasticity by age, and sometimes become incapable of motion.

THE LOWER LIMBS.

The LIMBS, *which carry and support the body,* form another remarkable part of our structure.

A. Each of them is composed, that is, the *upright* limbs, of three bones, the same number as in the arm: the two lower, called the *tibia*, and *fibula*, between the knee and the ankle, supporting a single bone which joins immediately to the body, and is called the femur or thigh bone. But notwithstanding this general resemblance between the two sets of limbs, there are some remarkable *differences*, which are adapted still further to increase our *devout* admiration of the wisdom and intelligence exhibited in the animal frame.

Below the knee the limb swings backwards; below the elbow, it is the reverse. We can assign no *natural* reason why limbs, which otherwise are so similar, should have been hung so differently. But we see the advantage,—for let a person only reflect on the uncomfortable effects of an opposite arrangement.

The upper single bone in the lower limbs is much stronger than the upper single bone corresponding to it in the arm. Indeed, the thigh bone is the strongest bone in the frame. We observe the design. *This* bone has to sustain the weight of the body, and the additional weight of every burden we carry.

It is united to the hip by a ball and socket joint, as is the upper bone of the arm at the shoulder blade. But the socket at the shoulder is shallow; while that of the hip is the deepest in the whole body. "This," says Dr. Paley, "agrees well with the duties assigned to each part. The arm is an instrument of motion principally, if not solely, and accordingly re-

quires a shoaler socket to allow it a freer play.—Whereas the thigh bone forming a part of the column of the body, having to support the body, firmness was principally to be consulted." Upon *natural* principles, however, the deeper socket ought to have been at the shoulder. At the *hip* the pressure of the bone is never against the bottom of the receptacle, so as to tend *naturally*, as one might say, to deepen the cavity. At the shoulder, on the contrary, the head of the arm always forces into the cup in which it moves. The neck of the thigh bone is bent over, and enters sideways. Consequently, there

Fig. 16.

This figure exhibits the neck of the femur or thigh bone, bent over, and inserted by the head into the socket at *a*.

is no pressing inward at this joint. We see why the hip socket should be made deep to prevent the bone

from thrusting by, as it is not directly under the support: that is, we see the wisdom of God, but we discover no other cause. Every natural tendency that we can conceive of, would have been precisely the reverse. The same remark will apply to instances without number in the animal frame, where a happy construction is apparently the opposite of a natural effect, and can only be referred to a designing *Intelligence.*

B. This is certainly very skilful and striking; but I would ask why the necesity of the oblique position of the thigh bone?

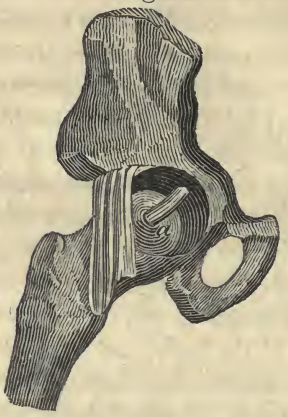
T. If you will endeavor in walking to place it in a straight position, by keeping the feet so far apart that the limbs shall be perfectly parallel to one another and perpendicular to the ground, you will find it produces a rolling effect when you rise from one foot to the other, as if mounted upon stilts. This is relieved by the *dishing* or oblique direction of the bones—and you will perceive it could be avoided in no other mode. Dr. Bell, in the Library of Useful Knowledge, has some curious remarks upon the form and position of the thigh bone, showing how it is calculated for strength in consequence of the obliquity, and in which he compares it to the dishing of a wheel.

But there is another provision in this remarkable structure which invites our attention,—the manner in which the hip joint is secured.

A. The joints in general, are united by means of a strong band of gristle encompassing the heads of the bones. This is the case in the ball and socket joint at

the shoulder. If a mechanic wanted to fasten a ball into a cup, so as to allow free play to the ball, he would adopt the same measure. Now, it is wonderful to observe, that in addition to this security, the hip, a far more important joint than the shoulder, and more dangerous to be dislocated, and from the position of the neck of the bone, more liable to dislocation, exhibits an additional security,—and a more mechanical, artificial contrivance one might be challenged to imagine. It is this: a short, strong, yet pliable ligament resembling a leathern thong, is inserted by one end into the head of the bone, and by the other into the bottom of the socket.—It is hardly practicable to break it. It will scarcely admit of being even extended. Its situation is such that it cannot be cut, without cleaving the bone. Whoever will reflect upon this single provision, taking into view its singular importance to this joint, and that it is not generally assigned to the other joints, and then how precisely it is what our own expedient would have been in a similar case,—must be disposed to say with Paley, "*It is an instance upon which I lay my hand.* For the purpose of addressing different understandings and different apprehensions, for the purpose of sentiment, for the purpose of exciting admiration of the Creator's works, we diversify our views, we multiply examples: but, for the purpose of strict argument, one clear instance is sufficient; and not only sufficient, but capable, perhaps, of generating a firmer assurance, than what can arise from a divided attention."

Fig. 17.



A part of the hip joint is here taken off, for the purpose of exhibiting the *round ligament a*, which is seen connecting the head of the thigh bone with the bottom of the socket. It allows considerable latitude of motion, at the same time it is the great safeguard against dislocation. It is hardly imaginable how great a force is necessary to stretch, still more to break this ligament;—yet so flexible is it as to oppose no impediment to the suppleness of the joint.

T. We will now close the description of the bones and joints, with another striking instance of wisdom and design in the formation of the foot.

THE FOOT.

A. The FOOT is composed of twenty-six little bones, united together by gristle, a very elastic substance under a hard pressure. So many joints impart the advantage of a spring—and of enabling the foot to conform itself to the surfaces of objects upon which we tread. Any one must be sensible of the incon-

venience of a *wooden* foot; and the inconvenience would be, it would have no spring; and would be incapable of suiting its shape to the inequalities upon which we stand or walk. But the number of bones is only a part of this admirable mechanism. The *arching* of the foot is an obvious proof of contrivance. If the bottom of the foot was perfectly flat, it is plain it must have had a heavy and uncomfortable effect. One may easily perceive this, by lashing the bottom of the foot to a strip of wood. There could be no spring with a *flat* foot. But as the construction is, the two extremities only of the foot rest upon the ground, while the elastic arch in the centre yields to the pressure, and causes the weight of the body when we walk, to play, as it were, upon a constant spring.

B. We now see the use of the heel, and it is a use which one would not immediately think of. It helps to form the arch.

T. But this is not all the use.

A. The heel is not directly under the leg, but extends back like a spur, and is united to the main body of the foot, by a very firm, but still a considerably springy joint. The effect of this is, when the heel touches the ground in walking, and it touches first,—in consequence of its being formed like a spur, and having a spring at the same time, the whole weight of the body does not come down with a sudden jolt;—there is not only a yielding in the point of support, but we descend in a curve, the centre of which is the ball of the heel. If it were not for this contrivance-

we should always walk as upon stilts. The leg would strike the ground, like a cane.

Fig. 18.

In this figure the foot is represented as descending to the ground in a semicircle from the point of the heel. Owing to this circumstance, in connexion with the elasticity of the parts, the force of the blow is diminished.

T. Are there any peculiarities in the feet or limbs of different animals, adapted to their particular necessities?

A. In the first place the *foot* of the monkey, as well as the hand exhibits a structure unlike that of the human species. The monkey's foot has an additional muscle. The muscles which move the toes are also differently disposed, and compel the animal to rest more upon the outer edge of the foot than upon the bottom. In the limbs of all animals, though not so much in the heavier species, there are sloping joints, or joints which make a bend. This enables the limbs to *give* or *spring* in some degree, under the weight of the body, so as to prevent a pounding stroke. In the horse, for example, we perceive the whole length of the limb from the body to the ground, is very far

from being a straight line. Besides the bends about midway of the hind legs, which are the limbs with which the animal has most occasion to spring—there is one upon every leg just above the hoof, called the fetlock joint. And then there is a spring even in the hoof. "The flatness of the hoof, which stretches out on each side, and the frog coming down in the middle between the quarters, adds greatly to the springiness of the foot. Ignorant smiths, by shaping and fixing the shoe improperly, often deprive the animal of the benefit of this provision. His foot strikes the ground with an unyielding blow, and inflammation and lameness at last ensue."

B. They are not always acquainted, it is likely, with this curious structure; but it is a pity so much suffering should be occasioned for the want of a little attention.

A. This admirable mechanism of the foot, which Providence has so kindly adapted to the wants of different animals, is strikingly exemplified in the case of the reindeer. "It inhabits a country covered with snow the greater part of the year, and its hoof is admirably formed for going over that cold and light substance without sinking into it or being frozen. The under side is covered entirely with hair, of a warm and close texture. And the hoof altogether is very broad, acting exactly like the snow shoes which men have constructed for giving them a large space to stand on their feet and thus to avoid sinking. Moreover, the deer spreads the hoof as wide as possible, when it touches the ground, but as this breadth would

be inconvenient in the air, by occasioning a greater resistance from the air, while he is moving along, no sooner does he lift the hoof, than the two parts into which it is cloven fall together, and so lessen the surface exposed to the air."

T. But there is another structure of the foot which will lead us still farther to admire the wisdom and contrivance exhibited in the animal mechanism.

A. It is that of the fly, by which it is enabled to walk upon a perpendicular wall.

B. This motion in these little insects always seems unaccountable, especially when they run so fast upon a glass window. The only reason I can think of is, that they have something *sticky* upon their feet,—or that there are rough places in the glass or wall by which they are able to climb up.

T. Any thing *adhesive* upon the foot would be a constant impediment, especially to an insect,—and to have to climb up upon points would be excessively inconvenient. They are enabled to perform this motion by a most curious philosophical contrivance. Can you describe it? It forms one of the innumerable instances in which we discover the powers of science, if we may so express it, subservient to the operations of *an all wise and Creative Intelligence.*

A. The air is said to exert a pressure upon bodies equal to between fourteen or fifteen pounds to every square inch of surface, so that upon one of our hands the weight of the atmosphere is more than *two hundred and fifty pounds.* The hand is not borne downward; because the air presses alike in every direction,

and therefore the downward pressure is resisted by an upward one precisely equal. But if the air on one side of the hand was removed, the weight upon the other side would remain unbalanced, and we should be sensible of the force exerted. An experiment is easily tried. If we put a piece of burning paper into a wine glass and then suddenly cover it with the hand, the hand will be holden fast to the glass. The reason is, the air has been in some measure expelled by the fire, so that there is now an unequal pressure upon the two surfaces of the hand, the greater pressure being above, which produces the effect we experience. If we could press our foot upon the floor with sufficient force to make the sole absolutely touch at every point, and perfectly expel every particle of the atmosphere, there would be the same effect. A foot of the common size would be holden down with a weight more than equal to that of a barrel of flour; it could no more be lifted than if such a weight were placed upon it, not till in some manner the sole was drawn up, beginning at one edge and gradually letting in the air, like raising a plaster. This is found to be the construction of the fly's foot. There is a skin or flap upon the sole which it can draw down so close upon the wall as to squeeze out the air completely, and the consequence is that the foot adheres with considerable force.

It has also been found that some of the large amphibious animals which inhabit the polar regions have the same formation of the foot, only upon a greater scale. By this means they are able to climb the floating masses of ice among which they live.

B. So we have here the principle of an *air pump.* How impossible to imagine any thing but intelligence, when we witness such examples of philosophical mechanism!

In the feet of *aquatic birds*, besides the *web* or membrane between the toes by which they are enabled to make a broader and more powerful stroke upon the water, another peculiarity has been less frequently noticed, viz. that their feet are situated further back than those of other birds. This enables them to thrust themselves forward more directly and with greater force in the water. The breast is not *tipped down*, when the animal strikes the water behind, because the breasts of all *aquatic* birds are peculiarly broad and covered with oily feathers which render them so buoyant, that this position of the feet is even necessary to enable the animal to dive, by means of the stroke of the feet so near the hinder extremity of the body. Their legs also are shorter in proportion than usual, in consequence of which the resistance of the water is diminished.

MUSCLES AND TENDONS.

A. We now come to another view of this wonderful workmanship. Having surveyed the admirable mechanism of the frame work, we are next to see the curious machinery which the All-wise Artificer has employed for putting all this apparatus in motion.

By what means are the motions of the bones performed?

A. By what are called the *muscles* and *tendons.* Though the flesh has the appearance, at first view, of

one general mass of substance spread over the bones, it is, in fact, composed of five hundred and twenty-seven separate strips of different sizes and shapes; and each of these is what is termed a muscle. They play freely over one another, and have a fatty matter between, which renders their motions easy. If the whole flesh of the body was dissected, as it would *naturally* separate, it would come apart in these five hundred and twenty seven strips, as smooth and as clean as so many straps of gum elastic. Each of them may be termed a rope to produce some particular motion. The middle is fleshy and red, and usually takes the name of the *muscle*. This portion is always the largest; then it goes on diminishing in size towards each extremity, where it terminates in a white leathery string or strap, which is called the tendon. Every muscle, with a few exceptions, is fastened between two different bones, going from one to the other; and the object is, to pull the bones together, or to draw them in any direction which the pulling would give them. Thus are all the motions of the bones performed. If we tie a strap of gum elastic to our thumb and finger, and spread them open so as to extend the strap, the force it will exert to draw them together, may give us a very tolerable idea of the action of a muscle upon the bones to which it is attached.

T. As the muscle, however, is not found to be any thing like gum elastic, what makes it contract so as to pull upon the bones?

A. The middle or fleshy part has the power of shortening itself at our will; and in some instances

the muscle seems to act of its own accord; this is about all the explanation our knowledge of the subject at present enables us to give; except that there are little shining threads, called the nerves, and which are fine branches of the spinal marrow or brain, that enter into all the muscles, and which, if divided or injured, the muscle is deprived of all its power. When the muscle shortens, it swells. If we bend the arm, and grasp it at the same time, a little above the elbow, we feel a swelling under the hand;—the muscle, which contracts, and produces the flexure, being situated in that part of the arm.

T. As you have a clear idea, I perceive, of a muscle, we will look at some of the examples of Creative skill and design in this part of our structure. If an artist were to contrive a machine with wires and strings to produce an imitation of our motions, how would he apply his apparatus to effect opposite movements with the same part?—to make the arm, for example, move backward and forward?

A. Wherever a string was employed to pull *forward* any part, there would be a corresponding one on the opposite side to draw it *back*; and all the strings would be divided into pairs for this purpose. It is exactly the same in the living structure. The muscles are in pairs. To move the arm forward there is a muscle before; to move it backward there is a muscle behind. It were difficult to conceive what could be more expressive of design.

B. In the five hundred and twenty-seven muscles, therefore, we have as many separate arguments of design, as there are *pairs*, into which the muscles

can be divided. If it could be imagined that a single example was possibly accidental ; that there *happens by chance*, to be a muscle to straighten the arm—and another to bend it, how are we to believe this of two hundred and fifty examples ; or that all the muscles happen accidentally to be paired ?

T. What is, if possible, a more wonderful evidence of design, it is said, the *flexor* muscles, (so named from a Latin word, signifying to bend,) have fibres of greater strength and more numerous than those of the *extensors*, or the muscles which merely extend and recover the limb ;—and that the flexors which have to make the principal effort, are fastened to better advantage, for the exertion of their power.

B. What manifest purpose and intelligence ! When we *bend* the arm, it is generally to lift a weight, but never when we *straighten* it ; and hence we require stronger flexors than extensors ; and the superior strength of the former is not owing, it seems, to exercise, but to the original structure of the muscle. There are more *strands* to the rope.

T. What part of the contrivance of a muscle is the *tendon*, or the white, leathery string in which the muscle usually terminates ?

A. Besides that the tendon is much more firm and tough than the muscle, and therefore more fit for fastening to the bone, for which purpose it is employed ; the muscle or fleshy part can be placed in any situation which is most convenient, and its motion be communicated by means of the tendons, like so many wires and strings to any part where the motion may be wanted. Thus, there are many tendons

which pass down to the fingers, while the muscles that pull them are situated out of the way in the arm above, without encumbering the wrist, palms, and delicate little members upon which they draw. It is like having the *water wheel* of a manufactory in a separate room, and communicating its power by bands and smaller machinery into the apartments where it is wanted.

T. Is there any particular wisdom discovered in the *structure* of a tendon ?

A. It is the perfection of a rope. We see the reason of its superiority upon mechanical principles, that is, in part we see it, from the higher skill which is employed as to the manner of laying the strands or fibres together, to give it the greatest strength. To understand what is necessary to the strength of a rope or cable, we must learn what has been the object of the improvements and patents in this manufacture. The first process in rope making, is placing the long fibres of the hemp side by side, or parallel to one another. The second, is spinning the hemp into yarns. And here the principle must be attended to, which goes through the whole process in forming a cable; which is, that the fibres of the hemp shall bear an equal strain. The third, is making the strands. The last step of the process is forming the strands into ropes. The difficulty of the art has been to make them bear alike, especially in great cables, and this has been the object in patent machinery. In the twisting of the yarns, and then of the strands, those which are on the outer surface must be more strecthed

than those near the centre; consequently, when there is a strain upon the rope, the outer fibres will break first and the others in succession. A rope, of a new patent, has been made, which is said to be many times stronger than any other cord of the same dimensions. The strands are *plaited*, (that is, interwoven or interlaced as in a splice or braid,) instead of being twisted. Now, if the strong tendon of the heel, or Achilles' tendon, be taken as an example, it will be found to consist of subdivisions, which are like the strands of a rope; but instead of being parallel or twisted, they are *plaited* or interwoven in a manner which could not be imitated in cordage by the turning of a wheel. *

B. It is wonderful how many different kinds of arts are exemplified in the animal structure. We have had that of the cabinet maker, and the telescope maker, and several others,—and now we have that of the rope maker in perfection.

T. You have given the celebrated *Dr. Bell's* account of the tendons, upon which you will find some observations in *Arnott on the Elements of Physics.* All other cords and bands wear out or are weakened by use. Is this the case with the muscles and tendons?

A. It is not, but the reverse. They become firmer and stronger by exercise; and it shows the kind wisdom of Providence, that when any employment happens to call for greater muscular effort in

* Dr. Bell.

any particular part, as that of the porter in the back; the sailor in the hands and arms, &c.; the strength necessary is made to arise from the very exertions which requires it. The necessity furnishes its own supply.

B. This is as though the sailor were to change a small rope into a *cable*, merely by fastening on an anchor. Creative power alone can accomplish such wonders.

T. The subject is of so much concern to us in many respects, that it is important the principle should be remembered. Do you recollect Dr. Bell's observations in his Animal Mechanics?

A. "Exercise," he remarks, "unfolds fully the muscular system, producing a full, bold outline of the limbs, at the same time that the joints are knit, small and clean. In the loins, thighs and legs of a dancer, we see the muscular system fully developed, and when we turn our attention to his puny and disproportioned arms, we acknowledge the cause, that in the one instance, exercise has produced perfection, and that in the other, the want of it, has occasioned deformity. Look to the legs of a poor Irishman, travelling to the harvest with bear feet; the thickness and roundness of the calf show that the foot and toes are free to prevent the exercise of the muscles of the leg. Look, again, to the leg of an English peasant, whose foot and ankle are tightly laced in a shoe with a wooden sole, and you will perceive from the manner in which he lifts his legs, that the play of the ankle, foot, and toes, is lost as much as if

he went on stilts, and, therefore, are his legs small and shapeless."

B. I have read that those who are employed at the different quays in London, to load and unload ships sometimes carry burthens which would almost kill a horse ; and that men who are accustomed to hunting will outrun horses, or at least can bear the exercise longer ; and even in walking, a man, who has been in the habit of it, will go further in a day than a horse can ; and if he do not accomplish it the first day, he will be able to continue his journey many days without inconvenience, while the horse will be exhausted with fatigue in much less time. It is said by travellers that Hottentots can *outstrip* horses ; and that the savages in America who hunt the elk pursue these animals, though they are as fleet as stags, till they tire them out and catch them. The civilized part of mankind seem not to be acquainted with their own strength ; and indeed they are so situated as to have little occasion for great physical exertions.—But we should praise the admirable wisdom with which the body is formed, to be capable of them when they are rendered necessary.

T. Though but a small part of the muscular power of which we are capable may be called into use in the ordinary occupations of life, the body that is strengthened by habits of temperance and exercise is best adapted to resist disease, and to withstand the effects of exposure. The vigor of the mind participates with that of the body, and professional writers observe that the very shape is injuriously affected by

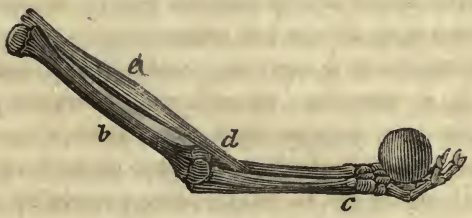
indolent and effeminate habits.—The muscles by which the joints are compressed and kept in their right position become relaxed; the consequence of which is, that the bones are gradually displaced, and produce deformity. The curvature of the spine and shoulders is supposed to be often owing to this cause; and hence exercise and active employments are now principally recommended to correct any such tendency, especially in those young persons who are in peculiar danger of so serious an evil, from the greater delicacy of their system, and more sedentary and retired habits. We very rarely observe any such imperfection among the laboring classes.

Anatomists notice a remarkable attention to mechanical principles, in the situation of the muscles,—and the manner in which they are applied to move the limbs.

A. First, there are always muscles where the bone would admit of any motion, but no where besides; that is, in all the five hundred and twenty-seven muscles, there is not one *mislaid*, or rendered useless by its situation; there is not one which pulls against the joint without effect; and further, there is not a single motion of which the form of the bone and joint will admit, but there is a muscle or set of muscles provided to produce that motion. This admirable harmony is one of the most striking evidences of an *Intelligent Architeect.* It is the same as in examining the rigging of a ship, to find through all the intricacy of the tackle, every rope suited to its place.

The manner in which the muscles apply their power to move the bones discovers a perfect acquaintance with the mechanical laws pertinent to such cases. Generally speaking, every muscle is fastened firmly at one end to a bone it cannot move, or which is sufficiently fast to pull by, and, at the other, to the bone it is intended to move or to pull upon. A cord tied between a door and the partition may give a very good idea of the action of a muscle. The moving bone is the door; the joint, is the hinge; while the shortening of the muscle moves the bone, in the same manner, as the shortening of the string moves the door. Thus a muscle is fastened to the bone of the upper arm which comes down over the elbow joint, and is attached to the arm below. By the contraction of this muscle the lower arm is raised up.

Fig. 19.



In this figure *b* represents the bone of the upper arm; *a*, the muscle which bends the fore arm, and which is inserted below the elbow into the radius at *d*. It will be seen that the shortening of this muscle must necessarily raise the arm, *d*, *c*.

T. And what is observable is, that the place where the muscle is fastened to the moving bone, is

so very near the joint. Here is an admirable attention to mechanical laws.

B. This does not seem very intelligible. One would think the muscle would pull to great disadvantage from being inserted so close to the joint. It would seem like drawing to a door with a string fastened just by the hinge, which every one knows would make it very hard to move the door. The elbow certainly appears to be bent with a great loss of mechanical power. It would seem far better if the muscle, which raises the fore arm had reached down to the hand, and been inserted at *c.* This would have given a greater purchase.

A. The advantage obtained is this, and the door is a good explanation. When the string is fastened very near the hinge, it requires a strong pull to draw the door; but then, if the strength is sufficient, it will make the door move much more swiftly than if the string were attached at a greater distance from the hinge. So, when a mechanic is raising a ladder, if he is able to lift it up by taking hold of one of the lower rounds, close to the foot, where the ladder turns upon the ground,—we may say, where the *hinge* is, in that case he will do the business much more quickly than if he were to begin at the farther end. Thus, the nearer the joint the muscle acts, the swifter the motion produced, provided the strength of the muscles is sufficient.

T. And for this, provision is made. The Creator has given sufficient *vital* power to the muscles to admit of this sacrifice of the mechanical or *lever* power,

as they evidently require to be stronger on account of their insertion so near the joint. Thus, a small thread would move a door, if applied to the handle, though it would snap asunder, if fastened close to the hinge. But let it be a strong cord and a powerful hand, and the nearer the hinge the better for a swift motion. Now, rapid motions are necessary to us in a thousand familiar actions.

B. I perceive it. The *rapidity* of the motion is frequently the first object required; as in cleaving wood, driving a nail, &c. Here a slow motion, however forcible would not answer the purpose. A giant could not *press* a wedge into a stick of timber. By the present arrangement, I see we have an application of the muscular power without which it would be insufficient for many actions quite necessary for our existence, and the *all-wise Artist* has rather chosen to strengthen the power itself, and subject it to some mechanical disadvantages, than not to assign it the best situation for the uses for which it is required. How amazing is that skill which has so wisely arranged every part of our frame!

T. We seem to understand this organization so well, I will venture upon another still more curious.

B. When we visit a manufactory we are eager to get some general idea of the machinery: how much more interested should we feel to obtain what insight we can into the works of our *Almighty* and *beneficent Creator!*

T. I was going to state a curious fact respecting the muscles, and I beg your attention. Between

every two ribs on each side of the body there are muscles to pull these ribs together, which is one part of the operation of breathing. It is necessary, you perceive, the motion should be capable of being performed very quickly, because we sometimes have occasion to breathe very quickly. How is this motion best effected?

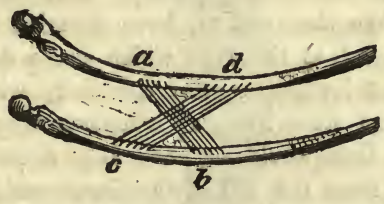
B. One would say, by having the muscles, that pull the ribs together, pass as *straight across*, as possible.

T. So it might seem; but it is just the reverse, in principle and fact. The muscles do *not* go directly across from bone to bone; that is, the strands or fibres of the muscles *slope* very much from one bone to the other. Can you explain it? If so, you will know something of a curious principle in mechanics and of the wisdom with which you are made at the same time.

A. The *door* seems to illustrate it very plainly. If the door of a room be thrown back against the partition, and a person, pulling it with a string, stand close to the door post,—in this situation, the line will slope along in the same direction very nearly with the door. Shortening the cord a foot or two now, he will perceive this sloping position of the line, produces a much quicker motion in the door than pulling in the same quantity, when the door has come to, so that the line is no longer flat with the door, but nearly perpendicular to it. Whoever tries the experiment will find it to be so. Now, the

sloping direction of the muscular fibres between the ribs must operate in the same way. It must produce a swifter motion than in any other position in which the muscles could be applied.

Fig. 20.



a, *d*, *c*, *b*, two ribs exhibiting a part of the intervening muscles, passing obliquely from bone to bone; by which direction of the muscles a mechanical advantage is obtained as to the quickness of the motion, for the purpose of respiration or breathing.

But there is a still more remarkable circumstance to be noticed in the structure before us, which shows the perfect foresight, and knowledge of mechanical laws exhibited in our frame. Do you not perceive that the sidelong action of these muscular strings *a*, *b*, must tend, while they pull the ribs together, to give a sidelong motion to the bones themselves, to cause the rib *a*, *d*, to move to the right and the rib *c*, *b*, to the left, and thus make them crowd against the places where their ends are inserted?

A. It shows creative wisdom in our structure, that this difficulty seems evidently to have been contemplated. There are two sets of muscles employ-

ed lying one upon another, which not only increase the muscular power, but which by sloping different ways, balance each other's sidelong tendency.

T. This single construction appears to me one of the most striking evidences of design in the animal frame.

B. When the tendons, have occasion to make a sudden bend, as those do which come down and turn at the instep to raise the foot, what is to prevent them from rising up whenever they shorten and pull? One would suppose the sinews would spring off from the top of the foot,—which would certainly be very awkward and unpleasant.

T. What if you should be told there are *cross straps* of ligament by which they are all confined down; exactly as a mechanic would do in a similar case? The straps are just under the skin and are very slippery and smooth so as so bind the sinews in their places, but allow them a free motion. The tendons at the wrist are bound down in this manner by a band resembling a lady's bracelet, as exhibited in this figure.

Fig. 21.

a, the *annular ligament* of the wrist, under which pass the tendons of the muscles of the fingers.

B. What manifest design ! One finds that to raise difficulties, is only preparing the way for some new demonstration of wisdom in this wonderful work of the Creator.

T. Can you mention any examples in the muscles, of that species of mechanical contrivance which is called the *pulley* ?

A. Sometimes the situation of parts is such that a motion is wanted, where for some reasons it is not

so well to place a muscle, or bring it to act in the usual way. For example. A muscle is necessary to draw *down* the lower jaw, and this is done by a muscle inserted *above* the jaw. Nothing is more common in mechanies, than pulling one way to make the object move in the very opposite. But then the rope must pass through a ring or pulley. The sailor pulls down, and the cask comes up. He has a pulley above through which his rope is roven. The same contrivance is adopted in the present instance; the muscle called the *digastric* muscle, descends from the side of the head, and passes through a loop in the neck *below* the jaw whence it *ascends* and is attached to the part to be drawn.

Fig. 22.

a, the *digastric muscle*, which is represented as coming down and passing through a slit or ring in another muscle indicated by the line *b*. After leaving the ring where it is formed into a round, strong tendon, it again becomes fleshy, runs upward, and is inserted into the chin to draw the jaw down. *c*, is a bone called the *os-hyoides*, which seems to operate as a stay or brace; the muscle containing the loop is fastened at *d*.

B. I know not what contrivance could be more plain, nor how any one can look upon it, without being persuaded of a desiging intelligence.

T. We have another example of the same kind in the *trochlear* muscle of the eye, from a Latin word signifying a *pulley*.

A. This muscle arises from the bottom of the orbit or socket, and then comes forward and passes through a loop on the inner edge of the socket, in advance of the level of the eye, whence it returns and is fastened to the ball: of course, when the muscle contracts it rolls the eye. It operates exactly in the same manner as a rope in a ship is carried over a block or round a stay, in order to make it pull in the direction which is wanted; or, as in raising one end of a stone pillar, the rope is passed forward of the object, and then is reverted through a ring or pulley as at *a*, in the following figure, and attached to the weight to be drawn up.

Fig. 23.

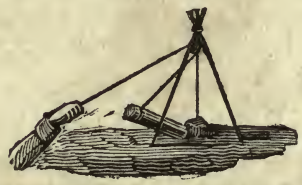


Fig. 24.

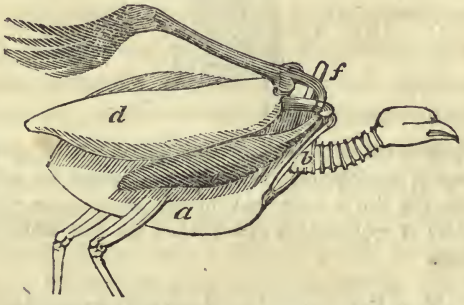
e, the *trochlear muscle*, which arises at the bottom of the socket of the eye, and passes upward and forward like the rope in the figure 23, till it reaches the pulley at *d*, on the inner edge of the bony rim around the front of the eye, where it is turned backwards, and inserted into the top of the ball.

T. There is quite as curious an example in the wing of the bird.

A. It is necessary the weight of the bird should hang below the wings, so as to balance the body in the air, and prevent it from turning over ;—for the weight of the body under the wings is the same as the ballast of a vessel under the sails. This requires that the muscles which constitute the principal part of the weight, should be disposed as much as possible upon the breast, and this principle we find to be observed. Every one who has seen a fowl upon the table, knows that upon the back, above the wing, there is only a mere skin. But the question arises, if the muscles, which are wanted to raise the wings, are situated beneath them, how are the wings to be elevated in the act of flying? As the muscle can only contract *downwards*, how is this to produce a

rising motion? The contrivance which a mechanic would have employed is that which is actually adopted. The tendon of the muscle passes up from the breast, above the wings, and is there inflected through a ring or pulley, and fastened to the top of the wing bone, and is thus enabled to perform the service required.

Fig. 25.



d, and *c*, the *two pectoral or breast* muscles dissected and raised from the breast bone *a*: *d*, being the larger muscle for drawing down the wing; and *c*, the elevating muscle. The tendon of *c*, is represented above the wing joint at *f*, elevated by a pin and inserted into the wing bone, a short distance from the joint.

B. How curious to notice the exact resemblance in the manner in which the *gaff of a vessel* is drawn up on which the sail is spread, and that which is here employed in raising and expanding the wing!

Fig. 26.

c, the gaff or rod upon which the sail is suspended, elevated by a rope *b*, passing through a pulley at *a*, above the sail, exactly as in the bird's wing, and for the same reason, viz. the necessity of applying the power below the part which is to be raised.

T. You have mentioned several examples which illustrate applications of the mechanical powers in the animal structure, which are among the most confessed proofs of skill and contrivance in our own mechanism. Besides many more that might be added, there is one which Dr. Paley calls, "that most exquisite of all contrivances, the *nictitating* membrane," (from a Latin word, signifying to wink,) which is found in the eyes of birds and of many quadrupeds.

A. The white skin which we sometimes see fowls and birds suddenly twitching over their eye balls, is this membrane, "and the use is to sweep the

eye, which it does in an instant; to spread over it the lachrymal humor; to defend it also from sudden injuries; yet not totally, when drawn over the pupil, to shut out the light. The commodiousness with which it lies folded up in one corner of the eye, ready for use and action, and the quickness with which it executes its purpose, are properties known and obvious to every observer." But what is equally admirable, is the manner in which it performs its office. It is an elastic substance, like Indian rubber, and when drawn out, returns *of its own accord*, thus saving the necessity of a muscle for this purpose.

We are next to notice what the French Academicians call the *marvellous mechanism*, by which this membrane is drawn over the eye. There is a string or tendon attached to the edge of the curtain, and which is connected with a muscle in the back part of the eye. When the muscle exerts itself, the membrane, by means of the communicating thread, is instantly drawn over the eye ball. But what is so deservedly called *marvellous* in this construction, is this. "The muscle which pulls the membrane, *is passed through a loop formed by another muscle;* and is there inflected, as if it were round a pulley. This is a peculiarity, and observe the advantage of it. A single muscle with a straight tendon, which is the common muscular form, would have been sufficient, if it had the power to draw far enough. But the contraction necessary to draw the membrane over the whole eye, required a longer muscle than could lie straight at the bottom of the eye. Therefore, in

order to have a greater length in a less compass, the cord of the main muscle makes an angle. This, so far, answered the end; but, still further, it makes an angle, not round a fixed pivot, but round a loop formed by another muscle; which second muscle, whenever it contracts, of course twitches the first muscle at the point of inflection, and thereby assists the action designed by both;" the main muscle and the loop muscle act at the same time, and thus conspire in the operation of drawing over the curtain.

B. One can hardly realize that this is a description of a *natural* structure. We acknowledge a Creator indeed, and must expect to discover the proofs of a Creator in our examination of his works; but yet the devoutest reception of the truth hardly seems to prepare us for observing without surprise, such actual demonstrations of skill as we perceive testifying to the existence, agency, and wisdom of the Deity in every object around us.

T. Does the motion of the muscles and tendons always depend upon our will?

A. It is happy they do not in every instance. The muscles immediately connected with life, or which move the *vital* organs, are independent of our will. They act, as far as we can perceive, of their own accord. We move the hand by our own choice, and its motion is never wanted, but when we are able to will it. But, as Paley says, "we should have enough to do, if we had to keep our hearts beating, our lungs in motion, and our stomachs at work. Did these things depend upon our attention they would leave us

leisure for nothing else. We must have been continually upon the watch and continually in fear, nor would this constitution have allowed of sleep." He might have added, we should hardly have performed these functions with the exactness and regularity they demand, had they been left to our vigilance and care.

B. This explains why *birds* are able to sleep, and yet poise themselves so exactly upon the perch *and keep from falling.* There is, I suppose, an involuntary action of the muscles by which they grasp the branch.

T. This may be partly the explanation, but it is not the whole. There is more mechanical contrivance for the benefit of the bird. In trussing a fowl, upon bending the legs toward the body, the cook finds the claws *close of their own accord.* Now this is the very position in which the bird *rests,* while it roosts upon its perch; and in this position it roosts in safety. By simply crooking its limbs it produces a contraction of the claws, which remain fast without any voluntary effort as it continues to sit. It is owing to this,—the muscle which pulls the claws together and which comes down the leg for that purpose, is carried round the joints in such a manner in its way to the toes, that it is long enough to reach perfectly the whole distance only when the animal stands upright,—and, therefore, in a sitting posture, the claws are necessarily contracted. In this way the bird is enabled to roost in safety, even when agitated by the winds.

Fig. 27.

a, the muscle going over the joint at *b*, and passing behind the leg, and around the joint at *c*, and then coming down behind the foot at *d*, it proceeds to the claws; and the weight of the bird bending the joints *b* and *c*, the muscle is bent at the same time, and the claws are drawn closely and firmly around the perch.

B. It has often appeared to me wonderful that birds should be able to rest so quietly upon a rocking branch, without losing their hold and falling off in their sleep. I see there is nothing overlooked by the wisdom of the Creator, and that not even a sparrow alights without him.

A. "In some animals which are sometimes obliged to stand for a great length of time, we find curious contrivances for assisting the action of the muscles. Thus, the sea birds, as the heron, which wade upon the shores of the sea and in the marches for

fish and reptiles, their natural food, had long excited the curiosity of naturalists, by the length of time in which they would stand motionless, expecting their prey. At last it was found, that in the lower extremity of the thigh bone there is a deep cavity into which a corresponding projection in the leg can be shut at the pleasure of the animal. The thigh and leg being thus firmly locked together, and to all intents and purposes, constituting but one piece, no muscular power is necessary to keep them extended."

ALIMENTARY ORGANS.

T. You have attended to some of the principal manifestations of creative wisdom exhibited in the *Senses;* in the frame work of the animal structure, the *bones;* and the *muscles* by which they are put in motion: We shall now notice the no less striking displays of design and wisdom which appear in the means provided to sustain the body, and preserve it in life and vigor. The *alimentary apparatus*, or that for nourishing the system, brings into view a new class of phenomena. We shall first describe the MOUTH.

THE MOUTH.

A. "In comparing the different animals," says Dr. Paley, "I know no part of their structure which exhibits greater variety, or in that variety a nicer accommodation to their respective convenience, than that which is seen in the different formation of their *mouths*. Whether the purpose be the reception of aliment merely, or the catching of prey, the picking up of seeds, the cropping of herbage, the extraction of juices, the suction of liquids, the breaking and grinding of food the taste of that food, together with the respiration of air, and in conjunction with the utterance of sound; these various offices are assigned to this one part, and in different species, provided for, as they are wanted by its different constitution. In the human species, forasmuch as there are hands to convey the food to the mouth, the mouth is flat, and by reason of its flatness fitted only for *reception*. Whereas the projecting jaws, &c. of the dog and his affinities, enable them to apply their mouths to *snatch* and *seize* the object of their pursuit.

The full lips, the rough tongue, the corrugated cartilaginous palate, the points and ridges in the roof of the mouth, directed backwards, which assist grazing animals in swallowing their food, the broad cutting teeth of the ox, the deer, the horse and the sheep, qualify this tribe for *browsing* upon their pasture. The retiring under jaw of the swine *works in the grounds*, after the protruding snout, like a prong or ploughshare,

has made its way to the roots upon which it feeds. A conformation, so happy, was not the gift of chance.

In *birds* this organ assumes a new character; new, both in substance and in form, but in both, wonderfully adapted to the wants and uses of a distinct mode of existence. The sharp edge and tempered point of the *sparrow's* bill, picks almost every kind of seed from its concealment in the plant; and not only so, but hulls the grain, breaks and shatters the coats of the seed, in order to get at the kernel. The *hooked* beak of the hawk tribe, separates the flesh from the bones of the animals which it feeds upon, almost with the clearness and precision of a dissector's knife.

Every thing about the animal *mouth* is mechanical. The teeth of lobsters, work one against another, like the sides of a pair of shears. In many insects, the mouth is converted into a pump or sucker, fitted at the end, sometimes with pincers; by which double provision, viz. of the tube and the penetrating form of the point, the insect first bores the necessary opening and then extracts the juices. And, what is most extraordinary of all, one sort of mouth, as the occasion requires, shall be changed into another. The caterpillar could not live without teeth; in several species, the butterfly formed from it, could not use them. The old teeth therefore, are cast off, and a new and totally different apparatus assumes their place in the fly. Thus, through the whole animal kingdom, the form of the mouth or the appendages attached to it, are kindly adaptedto the necessities of the creature.

It is said that quadrupeds, apes not excepted, have fewer muscles in the lips than are met with in the human species ; of course, they have less variety in the motions of the mouth, which is probably one reason they are not capable of imitating the human voice, or of uttering articulate sounds; and adds another item to the innumerable proofs that nature has placed an original barrier between ourselves and every being she has placed around us in the animal world.

T. Among all the parts and powers which belong to this curious structure, none are perhaps more remarkable, or more plainly evince contrivance and design, than the instruments provided for breaking and bruising the aliment, viz. the TEETH.

THE TEETH.

A. They form the same proofs of purpose and intention, as a knife for cutting, or a mill for grinding. No other bone in the body has any tendency to shoot out little pegs, except the very two, where it would be difficult to dispense with them. We perceive design, and that is all ; for it is no explanation to say there is a pulp within the sockets, which forms and makes these teeth. The pulp is a part of the provision, and the question still recurs, how came it in the jaws alone ? As the teeth do not admit, like our other bones, of being covered with flesh to preserve them from the air, to which no bone in the body would bear to be exposed, they are plaited over with a glassy substance, called *enamel,* which gives them also another advantage, that of superior

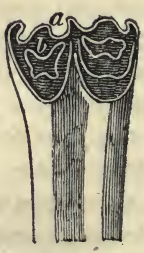
hardness. They consists of a proper mixture of cutters and grinders suited to our food, and the due preparation of it for the stomach. The jaws are so constructed, and the teeth so situated in them, that when either cutters or grinders are engaged, and both are not usually wanted at once, the others are not permitted to touch, or to wear upon one another. Again, the teeth do not commonly make their appearance in the mouth during the period of infancy, when they would be worse than useless. Lastly, as the teeth are needed before the jaws have attained their full size, there is provision for a *second*, or *suppletory* set when the bones of the jaws have grown so large, that it would be impossible the first should sit compact and occupy the whole extent of the gums.

Another thing observable in the teeth is, they are shed in succession, so as not to leave an interval in which we are without a sufficient number.—The *elephant* sheds his teeth, but not, it is said, in our manner. An account given of this matter is very curious, that having never more than eight grinders, often no more than four, an upper and under on each side, the shedding of one of which would of course leave a side of his mouth very much disabled for masticating his food, his second teeth, or rather the succeeding parts of the same tooth, always come up behind the first, and the one continues to serve till the others are ready to take their places.

The wisdom of Providence appears in adapting the teeth of different animals to the nature of their stomachs. It is one of the most striking instances of

that wonderful design we discover in the animal system. If the nature of the stomach be such as is the case in cats, tigers, lions, &c. that it will only digest animal food—the teeth are particularly fitted for tearing and separating flesh. On the contrary, if the nature of the digestive organs be such as to require vegetable food, as in the horse, ox, and many others, the teeth are flat, rough and of large surface resembling a millstone, and fitted only for grinding. The grinder of a horse or an ox, is a mechanical curiosity. There are ridges of the hardest enamel which rise up above the surface and run down to a considerable depth. These ridges are filled in between with a somewhat softer substance resembling marble ; the consequence of which is, that the spaces *wear* away easier than the ridges, and thus the tooth is kept always rough and fit for the operation of breaking and grinding the vegetable substances upon which the animal lives.

Fig. 28.



A *Grinder*, or one of the *Molares* of a horse, (from a Latin word signifying a mill stone) ; *a*. the *enamel* forming a raised edge around the tooth : the white lines in the middle representing the plates of enamel in the interior of the tooth, *b*. the earthy part interposed, which, by wearing away more easily, leaves the ridges of enamel projecting above.

B. How perfectly is the object accomplished by this admirable contrivance! A *millwright* would be puzzled to say how two surfaces could be made to grind continually upon one another without requiring to be *picked;* always wearing away—and yet for years preserving nearly the same projecting elevation upon the surface. We *here* see the solution of this mechanical problem.

A. Another remarkable structure appears in the other teeth, viz. the *cutting* teeth, for the benefit of certain animals. It is seen in the *gnawing* animals, such as the squirrel, mouse, rat, &c. As these animals have occasion for sharp front teeth, there is, first, a curious provision for this purpose. The enamel is only upon the *forward* part of their gnawing teeth. The *back* part is of a softer kind of bone. The effect is, that the back naturally wears down and leaves the enamel in the form of a sharp edge. The front teeth of these animals resemble a *bevelled* tool, or a *chisel*, and it is owing to this happy construction. But they must necessarily wear away very fast, and wonderful as it may seem, it is said they run back nearly the whole length of the jaw, under the roots of the other teeth, in sockets provided for that purpose, from which they *shoot up*, as the edges wear down. It is exactly the same contrivance as the pencil cases in which the pencil is made to screw out, as the pencil is cut away.

B. What inexhaustible varieties of creative kindness and skill! I suppose, if it were not the nature

of these animals to gnaw upon hard substances, this singular growth of their teeth would prove an uncomfortable provision.

T. There is but little danger, with their existing habits and propensities, of their *neglecting* this precaution ; but it is said, that, if fed only upon soft substances, their teeth *will* grow so as to penetrate the head and destroy the life of the animal. Before dismissing the subject, there is another consummate evidence of design, viz. the wonderful relation between the different parts of the mouth.

A. The form of the teeth and the motions of the jaws in all animals always correspond. The mouths of the cat, wolf, dog and those animals which have teeth and digestive organs suited only for flesh which requires to be divided by an upward and downward motion, have the jaw constructed in such a manner as not to admit of any lateral or side way action, such as we notice in sheep, oxen, and the like, and which would have been useless to flesh eating animals. This could not be chance.—For what but design could have effected such harmony of construction between parts so entirely different as the stomach, the teeth, and the joints by which the mouth is opened and closed. The animal structure is full,—is made up of such *relations*. So completely is it carried through every part; every part is so fitted to connected parts; and that without the least *natural* tendency that we can see,—for what particular tendency can a jaw without grinding teeth have to unite itself to the head by a *joint* incapable of grinding,—this correspondency

is so perfect, that from one single bone, or fragment of a bone, the naturalist tells us the shape, motions, and habits of the animal.

T. The next remarkable example under this head is the structure of the THROAT.

THE THROAT.

A. The throat is the channel for conveying the food from the mouth to another set of apparatus, where the process of converting it into nourishment is to be completed. It might seem a simple provision to furnish a tube from the mouth to the stomach. But there are difficulties which afford new occasion to admire the consummate skill which has contrived every part of our frame. In the first place, we must be able to swallow with *ease*.

B. I do not see any occasion for much contrivance to enable the food to *drop down* the throat. One would naturally suppose that it would fall of its own accord.

A. I dare say you have heard of some exceptions, however, and the failure of one instance, might produce the most serious consequences. Many articles of food, are of a light and spongy nature, and if taken in great quantities, would not be liable to effect their descent by their own weight. But the still stronger case is that of the animals whose swallowing is not a descending, but an ascending operation. The contrivance is the most mechanical possible. There are muscular fibres or strings in the lining of the throat,

which run round the passage, and which, by drawing the throat together above the food, as the food proceeds, force it along in its descent. In the horse, ox, &c. which have to swallow in a direction contrary to the weight of the food, there is a *double set* of these forcing muscles, which cross one another around the throat, and act with a much greater power.

B. I have often wondered that these animals should be able to raise their drink and food with such perfect ease into their long necks. The most familiar circumstances, I perceive, furnish occasion to admit the skill and kindness of that Creator, who giveth to the beast his food, and whose tender mercies are over all his works.

T. But this is only a small part of the contrivance necessary in furnishing us with a *throat*.

A. The *lungs* open into the throat. The opening is called the *glottis*, and is situated in the upper part of the throat, just below the palate. It is necessary for breathing ; but still—a dangerous opening we perceive, from a place where a crumb of bread might be fatal, into the great channel through which all our food has to descend. But the foresight was equal to the peril. It is wonderful to notice how the danger has been avoided. The opening is covered with a small valve, or clapper, opening upwards, anatomist call it the *epiglottis*, which plays over the entrance, and which the food closes before it in its descent. Nor is this the whole of this beautiful contrivance. The glottis itself is so constructed, that it draws together, whenever any particle of liqui d

or solid substance attempts to enter it. Besides both these provisions, the passage into the lungs is made so sensitive to the least touch of any liquid or solid substance, even a drop of water, as to produce a convulsion or cough instantaneously, when a particle of food or drink attempts to go the wrong way, as it is called,—and forces it back with violence. The membrane which lines the passage from the *glottis* into the lungs, anatomists term it the *trachea*, "is perhaps the most sensible and irritable membrane of the whole body. It rejects the touch of a crumb of bread, or a drop of water, with a spasm which convulses the whole frame ; yet, left to itself and its proper office, the reception of air alone, nothing can be so quiet. It does not even make itself felt ; a man does not know that he *has* a trachea. The capacity of perceiving with such acuteness—this impatience of offence, yet perfect rest and ease, when let alone—are properties one would have thought not likely to reside in the same subject. It is to the junction, however, of these almost inconsistent qualities, in this as well as in some other delicate parts of the body, that we owe our safety and our comfort; our safety to their sensibility, our comfort, to their repose." What artist would venture upon so exquisite a piece of mechanism, as that of a valve which should be always *opening*, under a current of water, and which should never suffer a particle of the water to enter the vessel! "Reflect how frequently we swallow, how constantly we breathe. In a city feast, for

example, what deglutition, what anhelation, yet does this little cartilage, the epiglottis, so effectually interpose its office, so securely guard the entrance of the wind pipe, that whilst morsel after morsel, draught after draught, are coursing one another over it, an accident of a crumb, or a drop slipping into this passage (which nevertheless must be opened for the breath every second of time) excites, in the whole company, not only alarm by its danger, but surprise by its novelty. Not two guests are choked in a century."

B. This is the more wonderful, because the passage into the lungs is often continued open for an unusual length of time, as in the act of *gaping*. This must add to the danger, if we should happen to be swallowing at the same time.

A. It is said *this* danger is not permitted, for that the muscles employed in swallowing are so curiously connected with those necessary to produce a wide extension of the mouth, that the two acts cannot be performed together.

T. In passing in this manner from example to example of creative goodness and skill, I feel constantly, my young friends, the necessity of reminding you that the proofs of an intelligent and designing beneficence are not confined to selected cases. In taking a cursory survey, we notice those instances which may be most easily explained. But I trust you will be sensible that *an equal wisdom pervades the whole system of Creation*; and that seeing particular demonstrations will tend to confirm this *devout* conviction in your minds.

B. I presume a *benevolent providence* appears in adapting the structure of the throat to the wants of different animals.

T. Yes, there are many instances in which there seems to be an extraordinary organization of this part of animals to answer particular purposes. Among the most curious is that of the *sea turtle.* I hardly know an instance in which the care of the Creator is more distinctly seen than in the novel provision made for this animal. The whole cavity of the throat is hung round with a great number of *little pendants* resembling in form the *bobbins* employed in making lace; the lower extremities of which are furnished with a sharp point, so that they prevent the ascent of any thing solid, while they permit a free passage to liquids. This singular structure is marvellously contrived for the particular wants of this animal. As in their mode of swallowing, they often admit great quantities of water into their mouths, this provision enables them to *regurgitate,* or throw back, the superfluous liquid, without permitting the fishes and other marine substances on which they live to escape with it.

HUMAN VOICE

A. The HUMAN VOICE has been pronounced by a devout writer, "*the greatest masterpiece of the Creator.*"

It is by the air passing from the lungs through the little orifice termed the *glottis,* that the voice is

formed. In all other wind instruments it is necessary to have different pipes or orifices to produce different notes. But the wonder of the mechanism of the *glottis* is, that, from one and the same aperture, arise all the various modulations of which the human voice is capable.

The power of voice and language is not however, confined to the human species. A kind Providence has bestowed this means of communication upon other animals, so far as is necessary for them—and every one must be sensible they would labor under great privations, if they were incapable of some language to make known their wants, which they could not do in a variety of cases, as at remote distances, or in the dark, without the assistance of sound.

"Observe the different cries of the *cock*," says a lively German writer, "either when a dog, or a stranger enters the yard, or when a *hawk*, or some similar bird of prey, presents itself, or when he calls to or answers his mates. What mean those lamentable cries of the *turkey*? Behold her chicks, all on a sudden concealing themselves, and lying so quiet, that one would think they were dead. The mother looks upwards, and her anxiety is increased; but what does she see? a black point scarcely distinguishable, but which proves to be a bird of prey, which could not escape her vigilance. The bird of prey *disappears*, and the hen sets up a cry of joy. The language of the *dog* is so copious, various, and expressive, that it would be almost sufficient to fill a dictionary.

Here again we may admire the wisdom and goodness of the Supreme Being. What kind attention has he shewn toward animals, in giving them the power to express by sounds their wants and feelings. From their organization, and the nature of their minds it was impossible they should speak the language of man; but they would have been much to be pitied, and less useful to us, had the Creator entirely deprived them of the power of making themselves understood. God has given them proper organs to produce and vary a certain number of sounds; and such is their make, that each has particular and distinct sounds, by which they make themselves understood. In short, the Creator has given such force to the language of animals, as their nature would admit of, and all that was necessary in order for them to answer the end for which they were designed.

T. You say, the *language* of animals.

A. The *voice* of animals is not, strictly speaking, the same with *language*. By language is properly understood articulate sounds expressive of definite ideas, not natural, but acquired. This is the prerogative of man; though man at the same time participates with all other animals in being capable of expressing his wants and passions by natural and inarticulate *cries*. Here again we discover the wisdom and goodness of the Creator. The infant is enabled to make known its wants, and the mother to express her affection by this gift of nature, long before any power of communication has been formed by articulate language. *Herder* terms the natural voice the speech

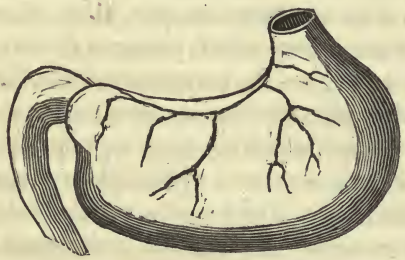
of the father and mother, the child and friend; and beautifully suggests that it forms a necessary means of cultivation in the first stages of life. It establishes an intercourse between the parent and offspring, when no other could be made. Its utility to us on a variety of occasions opens a wide field for acknowledging the kind purposes of Providence in endowing us with this faculty. A child sinking in the water or attacked by a furious animal is not left to depend upon such assistance as he may be able to command by being sufficiently near and sufficiently collected to discribe his danger. God has given a voice to fear more prompt and effectual than language. It is observable that he has imparted to distress much more power in this respect than to any other class of our emotions. We rush mechanically to the cry of pain and terror. He has given a language to misery to which every bosom responds; and we see the beneficence of this distinction. It shews the evident purpose of a kind Creator. The *misery* of others requires our attention, but their *happiness* does not.

T. It seems unnecessary to ask what demonstrations of design are discoverable in any other part of the living economy, after all we have perceived of the Creator's wisdom and beneficence in those which have been noticed. But we will take a cursory view of some of the principal which remain. Next to the wonderful mechanism of the parts you have described, is the *great chemical laboratory*, or the chief alimentary organ of the system, the STOMACH.

THE STOMACH.

A. The stomach is the organ in which the aliment is finally received, and where it waits to undergo a great chemical action, which consists in converting it into a pulpy substance, preparatory to its distribution to every part of the body. What may be first noticed, in view of wisdom and design, is the form and situation of this curious organ. It is placed in the centre of the cavity of the body, with its length across the body, and curving down in the middle, thus enabling it the better to receive and hold its contents.

Fig. 29.



In this plate of the *stomach*, it will be seen that the delivering orifice is situated in the most favorable manner for the purposes of the organ. Had it been placed below, nothing could have been retained.

T. Are there any *remarkable varieties* of the stomachs in different animals?

A. In some animals which are destitute of teeth, this organ possesses the power of a mill, to perform the operation of bruising and grinding their food.

This is the case with fowls and birds.—The *gizzard* is, in effect, their stomach; and in some birds it is capable of grinding the hardest substances, with the assistance of a liquor nature has provided in it. The gravel, which makes a part of their food, is to assist the operation of this mill.

B. This explains the marvellous stories related of the ostrich.—There was an account not long since, of one whose stomach was found quite full, among other articles, of such indigestible materials as old nails, glass, and brass buttons, which were partly worn away by the friction of the organ.

A. The *camel*, to enable it to traverse the sandy desarts of the countries in which it lives, is kindly furnished with an extraordinary kind of stomach, which answers among other purposes that of a water vessel, in which it can carry its drink. There are several little *muscular cisterns* attached to the stomach of the animal, which are kept separate, and which it fills from time to time as opportunities serve. The main stomach has, (principally on one side,) rows of purses or cells, side by side, with their mouths upwards, in length from six to nine inches, which are capable of admitting one's hand, and of holding from one pint to a quart of water or more. These purses or cells are numerous, and capable of holding when much distended, nearly thirty gallons of water. When the creature is thirsty the stomach contracts, and the water flows over the tops of the cells into the main stomach, to moisten the dry food, and help digestion. The greater the quantity of food there is in

the stomach, (of course the lateral pressure on the cells will be greater,) the more water will be forced from the purses or cells, and more is required to moisten the quantity of dry food. The mouths of the cells are too sensible of excitement, to admit any coarser nutriment than water. The fodder is never found in the cells unless the animal has been much tumbled after death, which readily accounts for the possibility of taking pure water from the stomach of the camel thirty days after the water is taken in. Their food once masticated and swallowed, is returned to the mouth, and there broken finer; its weight being increased by diminution of bulk, it easily passes by the coarser and lighter food into the stomach, and is pressed into the intestine for further digestion.

The *ox* is a still more curious instance of the diversity which Providence has kindly introduced in the structure of the stomach. This animal, and several other species of quadrupeds, have four stomachs, and are enabled in consequence to perform the singular process of *rumination*, or, as it is called, chewing the cud. It consists in repeating their mastication at a considerable interval after eating. These animals are deficient in upper front teeth; this circumstance, together with that of the peculiar toughness of the fibrous substances on which they live, and the great quantity they have to gather of such light and unnutritious food, render it a most happy provision by which the goodness of Providence has distinguished them, that they are able to *collect* their nourishment,

and *afterwards* finish the process of mastication at their convenience. It is received in the *coarse* state into the first stomach—and, after being masticated anew, passes successively into the others. The little *pellets* we see them throwing up into their mouths every few minutes, when they are lying down, are the forage they are quietly and leisurly taking up from the *receptacle* which they had been employed in replenishing.

T. Among all the curiosities of this organ, however, you have said nothing of the wonderful agent by which, principally, our food is digested.

A. The food is converted into a soft pulpy substance, chiefly by means of a chemical liquor called the *gastric juice*, which is continually secreted from the inner membrane of the stomach. It dissolves the contents of the stomach with astonishing rapidity. Soft and hard, flesh and vegetables, equally yield. The most solid bones cannot withstand its action.

B. I cannot conceive how it can be safe to have a liquid in our stomach, which is so very powerful as to dissolve bones and flesh; for the stomach *itself* is flesh, and one would think it would dissolve this also.

A. So any one would naturally imagine. We only know it will act upon dead, but not upon living flesh. Why this distinction—what produces it—is yet a secret. No chemist would think of pouring a liquid upon his hand, sufficiently powerful to dissolve a bone in the course of a few hours, without expecting his flesh would be instantly consumed. Within all the compass of his art, he knows of no chemical sub-

stance with which it could be done in safety. He has no acquaintance with any such agent, *that alone* excepted which is found in the living animal.

B. What a succession of wise and benevolent provisions! It is well we have adopted some methodical view of the animal structure; for otherwise it would have been impossible to have remembered a hundredth part of all these wonderful facts. So many were unknown to me, that I am sure I shall always in future entertain a stronger sense of the power *in which we live, and move, and have our being.*

T. You may deem it an inestimable acquisition, if, by the attention you have given to this subject, you are impressed with but *one* additional evidence of the wisdom and goodness of our adorable Creator. Any study that should have *this* effect—to cultivate a single conviction of his agency—is surely the noblest to which our minds can be directed. "In explaining these things," says an ancient Greek physician, "I esteem myself as composing a solemn hymn to the great Architect of our bodily frame; in which, I think, there is more true piety, than in sacrificing hecatombs of oxen, or in burning the most costly perfumes."

But to finish our survey of the apparatus which relates to nourishing the body.

A. After the food has been brought into a proper state by the chemistry which nature has provided in the stomach; this organ, by a tremulous, undulating motion, empties its contents thus altered, into another passage, leading from the stomach; where another

chemical substance is added, called the *bile*, which forms a still further process in this curious manufacture. It is then carried in its descent to the mouths of innumerable little tubes, called *lacteals*, from a Latin word signifying milk, which opening along in the surfaces of the intestines, suck up the *milky* fluid, into which the nutritive part of every substance we eat is *alike* converted in a short time by the inexplicable powers which Providence has assigned to the digestive organs. It hence makes its way by other vessels into the great current of the blood, by which it is distributed into every nook and corner of the system; and thus, what we receive with our *mouth*, arrives in a few hours *at our fingers' ends*.

THE HEART.

T. You now come to a most noble part of the frame—the engine by which the blood, containing the nutriment, is circulated over the body. You have reached what may be termed the *main-spring* of the animal structure. "*The wisdom of the Creator*," saith Hamburgher, "is in nothing seen more gloriously than in the heart;" though, strictly speaking, it is difficult to pronounce what part of the system is most essential; for it all acts together as one

perfect and connected whole. You may describe the heart.

A. The *heart*, with its connected machinery the *arteries and veins*, is the immediate contrivance by which the blood is distributed. It is as perfectly artificial as any machine whatever for conducting or forcing water. The *arteries* are the blood vessels which convey the blood from the heart to every part of the body. The *veins* are the vessels by which it is collected and returned; while the *heart* is the *engine* which is continually throwing it out in one direction and receiving it in another.

T. How is all this performed?

A. The heart is a hollow muscle, divided off into several rooms,—and is made upon the principle of a fire engine.

T. You have mentioned a striking comparison. We have found almost every kind of apparatus in the human frame;—but one would hardly have thought of hearing of a *fire engine.*

B. I believe it is not an imaginary resemblance, however.

T. By no means: there is a most extraordinary similarity; and to evince *the wisdom of the Creator* more perfectly, and observe how exactly one of the most ingenious productions of art has been anticipated in the living structure, you may describe a *fire engine.*

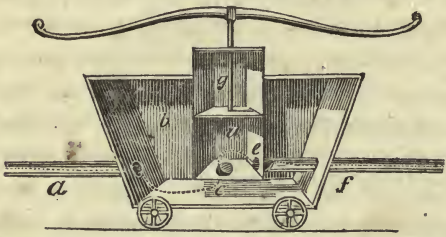
A. A fire engine requires, in the first place, to have *a room to recieve the water*, which in the best engines, is carried to it by a hose or leathern tube.

From this room, the water runs immediately through a little hole into a *second room, called the forcing room,* where it is forced out in a stream by simply applying a powerful pressure upon it. The water cannot run back again from the forcing room into the receiving room, when the pressure is applied, because there is a little *valve or door placed over the hole.* The door, swinging *inward* into the forcing room, is immediately crowded to and shut by the water, when it would endeavor to escape, as the forcing *commences;* and the water is therefore compelled to fly out into the hose or pipe provided for it. But when the forcing *ceases,* the door opens and lets in more water,—and so on continually. Such is a description of a fire engine of the simplest kind. *There are two of these engines in the heart*; each having its receiving and forcing rooms, with its little door between them; and each having its hoses to receive the blood and to convey it where it is required; making four rooms in the whole, and the heart being divided off into four apartments for that purpose. *With one engine,* the blood is received from every part of the body by two hoses of veins which terminate each in a single pipe, where they enter the heart. By another hose, which is termed an artery, the same engine forces all this blood into the lungs, where it has to undergo a certain change from the air. *The second engine,* in its turn, now receives the blood from the lungs by other hoses of veins; and again by another arterial hose distributes it over the whole system; whence it is returned to the heart,

to go over the same process of being first received from the body and propelled into the lungs,—and then received from the lungs and propelled into the body, by two separate engines, as long as life shall last.

Fig. 30.

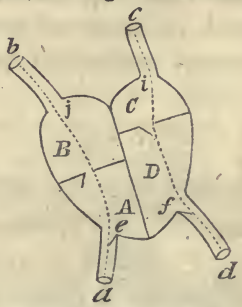
A Fire Engine of the simplest construction.



a, the receiving hose emptying the water into *b*, the receiving room,—whence it passes into *d*, the forcing room, throug h *c*, a little orifice with a valve or clapper over it, opening into the forcing room, the valve shutting down and closing the orifice, when the forcing instrument *g*, *d*, descends. The water is then forced out into *f*, the delivering hose, through *e*, another little orifice with a valve over it, which opens into the hose, and prevents the return of the water into the forcing room. The dotted line represents the course of the water.

Fig. 31.

A view of the heart, showing its resemblance to a fire engine.



B, A, C, D, the four rooms in the heart. *b*, *a*, *c*, *d*, four principal veins and arteries conveying the blood to and from the heart, —(the dotted lines representing the course.)

b, a vein bringing the blood from the body into B, the first receiving room, called the right auricle; whence it passes into A, the first forcing room, termed the right ventricle.—A small valve is represented playing over the orifice, and opening into the forcing room, to prevent the return of the blood, exactly as in the fire engine. *a*, the artery by which the blood is thrown into the lungs. *e*, the valve opening into this artery, and preventing the return of the blood, the same as in the engine.

—*Again*—

c, a vein by which the blood is returned from the lungs, and delivered into C, the second receiving room, called the left auricle; whence it passes into D, the second forcing room, termed the left ventricle; and hence into *d*, the great artery which distributes it over the body. The valves—the same as in the other rooms.

N. B. The situations, shapes and dimensions of the different parts are not exactly observed in the figure. In the heart, the auricles B, C, have more than one vein. The valves are also differently shaped from those in the figure. But the leading principles are seen; sufficient to show that, in construction, the heart is literally *a double fire engine.*

T. What *works* all this machinery ?

A. Each room of the heart seems to work itself. —The sides alternately *contract* and *expand* like a bellows ; so that the cavities are continually filling and discharging. The cause is unknown ; though some think it is owing to a peculiar quality of the blood.

T. In *fire engines* there is a body of compressed air, which is so contrived as to press the water out ; because the stroke of the pump, which is only *by jerks*, would not be capable of producing a steady motion. Is there any corresponding contrivance in the heart, since *here* too the strokes are only by intervals ?

A. It is stated, that the arteries which receive the rush of the blood from the heart are made *elastic* ; this being the case, they *enlarge* when the blood is thrown into them, and as soon as the discharge ceases, *contracting* by their own spring, they press the blood along in its course ; that is to say, *they answer the same purpose as the air vessel in the engine.*

B. One feels disposed to stop after this desrciption of the heart ; for it is impossible there can be any thing so wonderful in any other part of the body, as the mechanism you have described.

T. We express our surprise at finding means employed in the living structure resembling our own contrivances. But if they are such as would best answer the purpose, what else could we expect to find in the works of a *Divine Architect* ? But before you have quite done with the circulating system, you

must notice the care and solicitude with which the blood vessels are in many cases *disposed.*

A. A wound in an artery would be much more dangerous than in a vein ; because the blood rushes in the arteries with much greater force than in the veins, which only *return* the blood to the heart. It hence affords a striking evidence of a designing Providence, that the arteries lie deeper than the veins ; and, where particularly exposed, run along in a groove or a channel *cut into the very bone.* In the hands they pass down *between* the fingers, so that the familiar accident of a cross cut in the finger, can never separate one of them without cleaving the bone. How came *these* vessels to take a course so secure and defended ? What led them, more than the veins, to shun exposed situation, where they would have been liable to injury ? We know no other cause than an *Intelligence* which perceived the danger to be avoided.

B. A kind provision for heedless children !

T. Kind for every one ; as no parts are so liable to be wounded as the fingers.

A. As the *veins*, which are the vessels that return the blood to the heart, that is, all below the heart, have to ascend,—the blood has to mount in a direction opposite to that of its weight. Here, therefore, is the danger of a *reflow*—or a tendency contrary to the true circulation. Now, the universal provision against the flowing of water in a direction opposite to that desired, is a *valve* or *flood gate.* It is the same in the present instance. There are a great number of

little skins or thin membranes lying close down to the side of the vein, at suitable distances, and which allow a free passage to the stream when it pursues its ascending course, but thrust out and bar up the passage by the fluid getting behind them, whenever it would attempt to flow the other way.

B. Are there not the same valves in the vessels which convey the blood *from* the heart?

A. There are not: except one at the mouth of each artery which takes the blood from the heart. There are none stationed along in these vessels as in the veins; and they would have been of no use, as there is no danger of a reflux of the blood in its passage *from* the heart.

B. What endless examples of an all contriving wisdom! If one should attempt to account for the formation of these *loose skins* or valves, by supposing the force of the blood might have raised them up from the sides of the vessels, they must, according to this explanation, have been *numerous* in the arteries, where the strength of the current is the most powerful; *but we find there are none.* The operation of *natural* causes seems to be exactly reversed in this, as in many other parts of our wonderful structure.

T. There is one part of the apparatus concerned in the circulation of the blood, which you have omitted, viz. the lungs. You may briefly describe these; and we will take our leave of the *interior* of the animal frame.

THE LUNGS.

A. The LUNGS are two large spongy substances which fill the upper part of the chest, and are admirably fitted for the purpose they answer, viz. to *ventilate* the blood, or afford it the air by which it is purified and rendered fit for the support of life.

B. I thought you were going to say, for the purpose of *breathing*.

A. It is the same thing. The principal use of breathing is the introduction of air for the benefit of the blood ;—it being found, that the blood derives some of its most essential properties from the air which we inhale into the lungs. All the blood of the body is, for this purpose, thrown up into the lungs by the heart in the course of every circulation :—and here we may notice the *curious mechanism of the lungs.* They are full of air holes running in every direction ; and the blood is exposed to the air in innumerable vessels which are spread over the sides of these air holes, for this purpose.—Again, what we find in no other part of the body, these passages for the air are made of a substance like horn :—this preserves them open and free for the circulation of the air. How comes it, we may ask, they are not made of the same substance with the veins? We can only answer by referring to design. The *blood* can force its way through a *skin tube ;* but *air* would be liable to be obstructed. Lastly, there is a double passage for

breathing;—through the mouth, and by the nostrils. But for the latter, we could not breathe without difficulty, in taking our food. *The infant would find it impossible.*

COVERING OF ANIMALS.

T. You have now taken a general survey of the *internal* structure. You may close with a brief account of the admirable *covering* with which the whole is invested.

A. *The skin is a protection from the air,* which we know from experience, would occasion insupportable suffering, if it were immediately in contact with the flesh. For this and other purposes, there is a three-fold provision: there are three skins. The first, called the *epidermis,* or scarf skin, possesses no feeling, and covers the body, like a glove. It is *this* skin which is raised by a blister. The next is the seat of the color;—in Africans black,—in the European, white, &c. This is called the *rete mucosum.* Last of all, is the true skin; the anatomical expression is *cutis,* which in Latin signifies skin.

T. *Another use of the skin is to prevent the body from being overheated,* and to preserve an equal temperature in the system.

B. This must be some extraordinary contrivance.

A. There are innumerable little orifices, termed *pores,* in every part of the skin, though invisible to

the naked eye, through which a thin, watery liquid is continually issuing, called the *sweat*, when perceptible to the senses;—at other times, the *insensible perspiration*. If our sight was sufficiently keen, we should see every person in health, surrounded with a cloud of vapor.

B. But still, how is this to prevent the body from being overheated?

A. Upon a very simple principle, which is here beautifully introduced. If we wet our finger and hold it in the air, we are sensible of an immediate coolness in the finger. It is because the heat escapes with the moisture, as the finger dries; and the quicker we dry the finger by waving it in the air, the greater the coolness produced. The constant evaporation or drying up of the perspiration of the skin has the same effect;—and hence the danger of sitting by an open window, or in a current of air, when the perspiration is free.

B. This brings into view a new kindness of Providence, that the more the body is heated by weather or exercise, the more moisture is thrown out upon the surface. *The fire becomes its own extinguisher.* We now understand also how those marvellous accounts may all be true, of persons *setting in hot ovens* without being burned. The profuse perspiration prevents the effects of the heat.

T. Do we discover any striking *varieties* in the coverings of different animals?

A. "The *human* animal is the only one which is naked, and the only one which can clothe itself.

This is one of the properties which renders him an animal of all climates and of all seasons. He can adapt the warmth or lightness of his covering to the temperature of his habitation. Had he been born with a fleece upon his back, although he might have been comforted by its warmth in high latitudes, it would have oppressed him by its weight and heat, as the species spread toward the equator. What art however does for men, nature has in many instances done for those animals which are incapable of art. The clothing of its own accord changes with their necessities. This is particularly the case with that large tribe of quadrupeds which are covered with *furs*. Every dealer in hare skins and rabbit skins, knows how much the fur is thickened by the approach of winter. It seems to be a part of the same constitution and the same design, that wool, in hot countries, degenerates, as it is called, but in truth (most happily for the *animal's ease*) passes into hair; whilst, on the contrary, that hair in the dogs of the polar regions, is turned into wool, or something very like it. To which may be referred what naturalists have remarked, that bears, wolves, foxes, hares, &c. which do not take the water, have the fur much thicker on the back, than underneath; whereas, in the beaver, it is the thickest beneath, as are also the feathers in the water fowl. We know the final cause, the use and benefit, of all this; and we know no more.

T. What is there remarkable in the covering of *birds*?

A. On account of its peculiar lightness, smoothness, and warmth, it is singularly adapted to the uses of the animal. *A bird's wing is a mechanical wonder.* It may be doubted whether the most ingenious artist would have hit upon the construction, till he had seen it exemplified. He would have known there should be something to spread out, and be capable of folding up, and that it should be very light, and sufficiently strong, at the same time, to make a stroke upon the air. The probability is, he would have thought of a thin membrane like a piece of cloth, so contrived as to open and shut like a fan, which is actually the plan which has been adopted in artificial wings. But there must be one unavoidable imperfection in such a wing. If accidentally *torn*, it would be ruined for the bird's use. This difficulty is avoided in the bird's wing by the only imaginable contrivance which could have answered the purpose; and that is, having the wing composed of *distinct* feathers, sufficiently close, when united, to give the necessary stroke, but separating in case of any uunsual violence that would endanger a membrane, and then recovering their places by their own elasticity or springiness. *Such is the structure of a bird's wing.* Its ingenuity will still further appear, when we examine *a single feather.* If the beard or vane of a feather, that part we usually strip off when we make a pen, be stroked down toward the hollow or quill part, we find the little filaments or threads will stand out from the stem, and remain separate; but if they are smoothed back in their places they will reunite and become fastened together with

considerable force. They thus admirably answer the purposes of a wing; for *when parted by any violence* which would have torn instead of rumpling them, had they not been separate, *the bird can replace them with a few strokes of his bill.*

B. This explains why we see birds often so diligently engaged in stroking an oily substance over their feathers. It probably contains something *glutinous* to hold the filaments together.

A. We know of nothing glutinous which the weather would not harden or melt. It must be some mechanical contrivance; and *so it is.* Between every two filaments there are little hooks; on one filament curving up, and on the other, down, so as to catch over and fasten together, like the latch of a door.

In the feathers of the *ostrich,* this apparatus is wanting, and the consequence is easily seen; the filaments hang loose and form a sort of *down* merely, well adapted for the purposes of a fan, or for an ornament, but which would certainly have been an imperfection, had the bird, which it is not, been adapted for flight.

In the *body* feathers of all birds the lower filaments of the feather are not clasped together, but are mere furze or down. The clasps are confined to the *upper* part of the vane. We find, upon examination, that from the place where the clasps are discontinued and the downy part commences, the feathers are overlapped by the feathers behind like the shingles upon a house, and that the clasps are not wanted here for

the purpose they answer, where the feather is exposed to the water or air, viz. to produce a smooth, connected surface,—while the down in this *under* situation, is more useful for the warmth of the bird.

Fig. 32.

The body feather of a bird, exhibiting the discontinuance of the clasps at the lower part of the stem.

B. What a striking and beautiful design! If the clasps had been produced by a set of causes, constituted by accident, and acting as all *ignorant causes must act*, by a general operation, then we are at liberty to ask, why the apparatus was discontinued only at this part of the feather, where the occasion for it ceases, or where the feather is covered? What *natural* tendency could there be in *covering* the feather to prevent the formation of the little hooks? We see a regard to *utility*, and can give no other solution.

T. Did you ever notice another curious circumstance in this remarkable structure?

A. The filaments are *broad* and *flat*, like the sticks of a fan. Owing to this circumstance, they easily bend for the approach of one another, whilst in the other direction they bend with difficulty. Now, it is observable, that it is in this latter direction, the feathers strike upon the air and in which, conse-

quently, the greatest strength and power of resistance are wanted.

Also, the quill part is a curiosity. It consists of two sets of fibres, the one running *lengthwise*, which are those we separate when we make a pen; and the others passing *around* the quill, like the ferrules upon a cane, or the hoops upon a barrel. The rings secure the quill from being split. The hoops are a security to the staves. Hence it is, we are obliged to scrape a quill before we can get a split. We must in fact *unhoop the barrel*.

B. How many kinds of *arts* we have had exemplified in the living machine! *Here*, it seems, we have that of the *cooper*.—Speaking of the the covering of animals, is there any design, we can perceive, in the *difference of color?*

A. It is found, that heat will not escape so easily through a *white* surface. The colors of animals in very cold countries are remarkably inclined to white;—and animals are apt to become of this color, when removed to a high latitude. We can assign no other reason for this, but a beneficient appointment of Providence, for the comfort of the animal. The natives of hot countries, on the contrary, are more or less of a dark complexion.

B. But does not black absorb the heat, or, as is commonly said, draw the sun? and must it not therefore be an uncomfortable color, in those regions?

A. There are some recent experiments which seem to shew that a black color will protect the skin from the scorching effects of the sun's rays; and it is

well known it will *cool* quickest in the shade. *The African, therefore, derives a double benefit from his color* in his *own* climate; though, in a different situation, the provision would cease to be beneficial. We see here another violation of nature in his removal.

T. Having spoken of several particulars in which the wisdom and goodness of the Creator are exhibited in covering and protecting the body with an evident accommodation to the wants of men in different situations, and to the peculiar circumstances of different animals;—we will close our observations of an anatomical kind, by glancing at one further mark of Divine goodness, viz. in the REMEDIES naturally provided.

A. There are few cases in which prospective contrivance is more conspicuous; or in which we have more occasion to admire the providence of God, and his tender care for our preservation. One of the most striking is the provision for the union of broken bones. From the *situation* and *structure* of the bones, if they are broken, the injury must be irreparable, unless theys hould be capable of taking the cure principally upon *themselves*. The whole thickness of the flesh would have to be separated in the first instance; and then how to unite them, if this was to be a business of ours, would surpass our ingenuity. The provision, as is well known, consists in there oozing out from the broken extremities of the bone a soft fluid matter that soon turns into bone, and unites them together more firmly than before the fracture.

B. Just as in cementing a vessel, we apply some liquid substance which hardens and unites the parts; —except, that in the present instance, the *uniting matter is supplied by the fracture itself;* another of the innumerable instances in which our contrivances are but a rude and imperfect imitation of those which creative skill has employed in the human structure.

A. With regard to the union of bones, there are several exceptions, singularly observable and remarkable as evidences of design. There are some bones in which when broken, *true bone is never formed anew to repair the injury,* as is the general provision. When the arm is fractured, a bony matter exudes from the extremities, which finally surrounds them completely with a ring of bone. But when a piece of the *skull* is removed, *no new bone is produced;* nothing but a skinny or ligamentous substance is formed to fill the opening. So, when the *knee pan* is fractured, the pieces are always united in the same way. In either of these cases, if bone or callous was formed, with its ordinary *irregularity* of shape,—with a *projecting* ring over the fracture the cavity of the skull, or knee joint would be encroached on, and the most serious evils would ensue. Why the power of creating new substance like itself, should be denied to the skull and the knee pan alone, we can only explain by referring to an Architect who perceived the necessity of these exceptions.

Fig. 33.

The principal bones of the human frame, referring to former descriptions.

T. You have now taken a general survey of some of the principal marks of design and wisdom in our frame. You have seen one diversified exhibition of skill, far exceeding though strikingly analogous to some of the most ingenious contrivances of human

art. Whoever should refuse his *conviction* must be incapable, it should seem, of trusting to any conclusion in any case. The subject has not been pursued from any apprehension that *you* need to be confirmed in the belief of a Creator; but for the sake of *impression;* of multiplying the views which may lead you to think of God; and for the purpose of supplying further opportunity of *devout* sentiment and meditation.

It would now be proper to turn our attention to the intellectual and moral faculties. The *Natural Theology of the Mind*, you may well suppose, cannot be less replete with the indications of a wise and beneficent Author than the physical structure. But this must be reserved for another opportunity. There is one connected subject, that of *instincts*, which may be mentioned.

INSTINCTS.

A. We behold the *instinct* of animals admirably adapted to their different wants. In the *bird*, it is a peculiar sagacity for building a *nest*, in the *spider*, for spinning a *web*, in the *bee*, for forming a *honey comb.* The instinct is adapted to the nature of the animal. Were they to *exchange* their instincts, it would be fatal to them. The bird could not sit upon a web, or live in a honey comb. We have only to consider the innumerable species of animals—and

that every one has exactly the kind of instinct which is suitable for it, and we must be sensible how plainly it shows an *all disposing wisdom and goodness.* It is no explanation to say, the body of the spider affords a liquid which can be drawn out into threads, and is suitable for making a web, and, therefore, the insect *employs* the materials with which it finds itself supplied. For what leads it to know *how* to employ them, without instruction, as soon as it is born? We are therefore left to admire a striking display of benificence and design in the *distribution* of instinct; that every animal is equally furnished with the particular species of sagacity which is suitable to its wants.

Instinct forms one of the most pleasing and instructive parts of natural history, and one of the most delightful studies to every mind that loves to trace the beneficent care of the Creator. It is not confined to dumb animals; but we are to acknowledge the goodness, which has given us *instinct* as well as reason. It is by *instinct* infants manifest signs of fear when they are approached with a countenance or voice expressive of displeasure; and are soothed and pleased with gentle and tender expressions. We have many *instincts* which the merciful Author of our nature has given us, for a variety of occasions, when the powers of reason are not unfolded, or circumstances would prevent them from answering our purpose. Thus our preservation from danger often requires, that some action should be performed so suddenly that there is no time to think and determine.

What could save a person, when slipping upon the edge of a precipice, if he had no *instinct* to produce a sudden exertion, but must first consider his danger and *wait* the decision of his *understanding*?

T. You may mention some examples of this remarkable faculty in animals.

A. The *honey bee*, from the days of Virgil, has been celebrated for its sagacity in gathering its honey and wax, in fabricating its comb, and in rearing its young. But it has not till recently been discovered, that its works will bear such a critical examination of the mechanic and mathematician. It is a curious mathematical problem, what is the best manner of making a *frame of bones* laid side by side, and one upon another like a *honey-comb*, so as to produce the greatest strength, and the utmost possible saving of materials and labor? It was seen, that each of the boxes should be a figure of six sides, a hexagon. *Such is the form of the cells of the honey-comb.* It was also perceived, that the bottom of each box should not stand exactly upon the top of the one underneath, that is, not rim upon rim, but that every box should be placed so as to have three partitions meet on the under side, forming a buttress to strengthen the bottom. *Such also is the structure of the honey-comb.* It was further demonstrated, that the bottom of each box should not be a single plane or flat, like the bottom of a bucket, but should consist of three pieces making a spreading or obtuse angle with the sides of the box and also with one another. *Such again is*

the construction of the honey-comb. But another problem remained, viz: to determine the *precise* angle at which the three pieces ought to be united to render the structure perfect. "This is one of those problems, belonging to the higher parts of mathematics, which are called problems of *maxima and minima.* It has been resolved by some mathematicians, particularly by the ingenious Mr. Maclaurin, (one of the most distinguished of the disciples of Newton), by a fluxionary calculation to be found in the Transactions of the Royal Society of London. He has determined the angle required; and he found by the most exact mensuration the subject could admit, that it is the *very angle* in which the three planes in the bottom of the cell of a honey-comb do actually meet."

Another curious example of philosphical instinct is the web of the spider. The web usually consists of circular threads laid round upon straight ones which form the *stays* that fasten it to the wall. The *circular* threads are covered with a *glutinous* substance, and by these the food of the animal is caught. But the *straight* ones, which are more necessary to the web, are *not* adhesive, and are therefore not permitted to grapple with the fly, so as to be exposed to the danger of being broken by its violence. The same is true of the *uttermost* thread which *encompasses* the web, and which is of particular importance to its security. *This* is not adhesive. The most skilful artist could not have displayed more judgment.

T. Upon what grounds do you consider the in-

stincts of animals as directly referrible to an immediate Providence?

A. First, the very *perfection* of instinct shews that the animal does not act from any sagacity and reason of its own. If instinct is not to be ascribed to a *peculiar* providential guidance; if it is not a *blind* propensity in regard to the animal; a propensity prior to experience and independent of instruction; the bee has obtained a deeper insight into the principles of mathematics, than most of our own species. The *early period* at which animals discover their instinct, not only evinces the care and goodness of Providence, but that it is wholly an operation of Providence. The chicken which is hatched in an *oven*, and can have enjoyed no opportunity of learning, is not ignorant how to provide for itself like others of its kind. "When caterpillars are shaken from a tree in every direction, all of them immediately crawl toward the trunk and climb up, though they have never formerly been upon the ground." They lose no time in *reasoning* what they shall do.

B. But still, do not dumb creatures appear to *reflect* and *reason*? I think it is *Huber* who mentions that when bees discover that some *new* insect has been depradating in their hives, they will soon contrive an impediment to prevent it from entering a second time If it is a *broad bodied insect*, they will narrow the door. If a *long and slender* one, they will put up an extra partition so very near the entrance, as not to permit a body of that length to conform itself to the passage. It is commonly said, I know not with what

truth, that if a dog, in pursuit of his master, arrives at a place where three roads meet, he will *scent* only upon two, without repeating the experiment upon the third, as if he *reasoned*, that this of course *must* be the right.

T. It would be unfortunate indeed, a very imperfect provision for the safety and comfort of the animal, if instinct was incapable of adapting itself in any measure to circumstances; if it had been so very blind an impulse as not to have *any* discretion; confined to one invariable course; and of no use in any novelty of situation. But still this does not exalt instinct to the rank of human intelligence, by which the Creator has placed an immeasurable distance between us and the irrational animals. What seems to be the *limit* of instinct?

A. From all we see of instinct, it appears to relate principally to the preservation of the animal and the continuance of the species. It enables the bird to build its nest, and provide for its young. It is a guide to the animal in *given instances*. Here it is infallible: and here it ends. It may be a *reasoning* faculty to a certain extent, as is often necessary, and as therefore it might have been expected from the benevolence of the Creator it would have been. Still, whatever it *be*, it seems always to *have been*. We know of no improvement in instinct. We discover no capacity of advancement; no ability of self cultivation. Society has done nothing, apparently, for the tribes of instinct, as it has done for our species. The animals that *herd together* remain as much the same,

from generation to generation, as the most *solitary*. We discover no one inclining to become an instructer to its own kind. They exhibit no capacities susceptible of being unfolded, perfected, or changed by bringing their ideas into a common stock. In short, the instinct of animals seems to want the essential principle of *voluntary improvement*, and, therefore, of *accountability*. To man is assigned the high and noble prerogative of an intelligence susceptible of an unbounded progress; intrusted to his own cultivation; capable of advancing the welfare of his species; and therefore laying the foundation of his moral and religious obligations to that *Being* who has exalted him to a rank so glorious.

T. You have now attended to some of the principal instances of Creative wisdom and goodness in the *animal* frame. I presume you have noticed the remark of Dr. Paley, that, in his opinion, "a designed and studied mechanism is, in general, more evident in animals than in plants; and that it is unnecessary to dwell upon a weaker argument, when a stronger is at hand." It is true, plants are of a more simple structure than animals; and there is certainly no occasion to strengthen the proofs of a Divine and benevolent Providence you have already related. But not to overlook a department of nature so familiar and beautiful as the vegetable kingdom, you may mention what you remember as to the uses and designs we discover in *plants*.

PLANTS.

A. Plants the most valuable for food are the most abundant and easily procured. It is an evident design also of a kind Providence, that plants are so various, as to be adapted to all changes and vicissitudes of weather and climate—the seasons which are less favorable to some are propitious to others. Diversities of soil—of hill and valley—are so many different advantages for different vegetables, and for the same vegetable.

It agrees with the same view of the subject to remark that fruits are not, (which they might have been), ready altogether, but that they ripen in succession throughout a great part of the year; some in summer; some in autumn; and that some require the slow maturation of the winter, and supply the spring. The most hardy of all plants is the *grass*. It will bear to be trodden by the animals which have to *walk over* the fields on which they graze. Of all productions of the earth this is the most universal; happily for the numerous tribes whose indispensable food it is, and which could neither transport it themselves, nor for which, valuable as they are to man, could he afford to procure so bulky an article from any considerable distance.

The *warmer* latitudes abound in fruits adapted to *allay thirst and mitigate heat*; such as the lime, the lemon, the orange, the melon, and all acid and

watery vegetables, in peculiar variety and perfection. Those plants and fruits particularly suited to prevent *putridity*, which is one of the greatest dangers of hot climates, are remarkably abundant in such climates. These are the spices, the pepper, clove, &c. and other aromatic vegetables which are obtained from the warm countries.

"One cannot open a volume of travels, but some shrub or plant is made known to us, peculiarly adapted to the clime. In the Brazils a cane is found, which on being cut below a joint, dispenses a cool, pleasant liquid, which instantly quenches the most burning thirst; and Prince Maximilian, when traveling in America in 1816, quenched his thirst by drinking the water found within the leaves of the bromelia."

Mr. Elphinstone says, *the water melon*, the most juicy of fruits, is found in profusion amid the arid deserts of western Africa; and adds, "that it is really a subject of wonder to see a melon, three or four feet in circumference, growing from a stalk, as slender as that of a common melon, in the dry sand of the desert."

Mr. Barrow thus describes the curious vegetable, the *pitcher plant*. "To the foot stalk of each leaf is attached a bag, girt round with a lid. Contrary to the usual effect, *this lid opens in wet and dewy hours*, and, when the pitcher is full, the lid *closes;* when this store of moisture is absorbed by the plant, the lid opens again."—(*Thoughts on Domestic Education.*)

"The food afforded by the soil in each climate," says a late philosophical author, "is admirably adapted to the maintenance of the organic constitution in health, and to the supply of the muscular energy requisite for the particular wants of the situation. *In the Arctic Regions no farinaceous food ripens*; but on putting the question to Dr. Richardson, how he accustomed to the bread and vegetables of the temperarate regions, was able to endure the pure animal diet, which formed his only support on his expedition to the shores of the Polar Sea, along with Capt. Franklin, he replied, that the effects of the extreme dry cold to which they were exposed, living, as they did, constantly in the open air, was to produce a desire for the most stimulating food, they could obtain; that *bread* in such a climate was not only *not desired*, but comparatively impotent as an article of diet; that pure animal food, and the fatter the better, was the only sustenance that maintained the tone of the corporeal system, but that when it was abundant, (and the quantity required was much greater than in milder latitudes), delightful vigor and buoyancy of mind and body were enjoyed, that rendered life highly agreeable." Here, therefore, we see an admirable adaptation of the food to the climate;—that while vegetable productions are few in these cold regions, *the oily animal substances are remarkably abundan.*

T. Do we discover any remarkable appearance of design in the *structure* of plants?

A. Every plant furnishes occasion for admiring the wisdom of the Creator. The seed and the fruit are the most important parts. The seed is wanted to reproduce the plant; and it is generally for the fruit the plant is useful. We are first to observe the particular provisions which are made for both the seed and the fruit in the structure of the plant.

T. This is an interesting portion of the subject, and you may be a little particular; first, as to *the parts which produce the fruit.*

A. They are called by botanists the *pointals* and *stamens.* They are the small fine threads we generally see inside the flower. The *pointal* is commonly situated in the middle, terminating in a knob at the top, which is called the *stigma*, and, in another at the bottom, which is termed the *germ*, and which is to become the fruit, and contain the seed. The *stamens* usually surround the pointal in a circle; bearing on their upper extremities what are called the *anthers*, which produce a dust, that is named the *farina* or *pollen.* It is that yellow powder which comes off upon the finger in a full blown flower. Its use is to lodge upon the pointal, where it produces a certain effect, which is found to be necessary for the formation of the fruit. Remove this dust and the plant will produce nothing.

Whatever the form and situation of these curious parts of the plant, without which it would be barren, we discover an extraordinary degree of care exhibited by nature, to preserve them. First, they are not *exposed*, till it is necessary, or till their office is

wanted, which is only when the plant is reaching its full growth, and then they perform their duty in a very short time. Till this period, they are carefully and curiously wrapt up and protected, as we see in the bud of a rose or the sheathe of a corn plant.

The *buds* of some trees, such as the balm of Gilead and the horse chestnut, are uncommonly large during the winter, and are then covered over with a resinous or gummy substance. We behold Creative design and wisdom in this arrangement. In all these trees, the pointals and stamens are very considerably *advanced* when the *winter* overtakes them. The unusual size of the buds is adapted to this circumstance. "They are wrapped up in these buds with a compactness which no art can imitate. This is not all. The bud itself is inclosed in scales—which scales are formed from the remains of past leaves and the rudiments of future ones. Neither is this the whole. In the coldest climates, a third provision is added by the bud having a coat of gum or rosin, which being congealed, resists the strongest frost. On the approach of warm weather, the gum is softened, and ceases to be a hindrance to the leaves and flowers. All this care is a part of that system of provisions which has for its object the consummation and perfection of the seeds.

The *poppy*, while it is growing, hangs *down* its head, and in this position it is impenetrable by rain. When the head has acquired its size, and is ready to open, the stalk *erects* itself for the purpose, it should seem, of presenting the flower, and with the flow-

er, the seed and fruit parts to the genial influence of the sun's rays. "This always struck me," adds Dr. Paley, "as a curious property, and specifically as well as originally provided for in the constitution of the plant; for if the stem be only bent by the *weight* of the head, how comes it to straighten itself, when the head is is the heaviest? These instances shew the attention of nature, he observes, to the principal object, the safety and maturation of the parts upon which the seed depends.

Some plants, as the pea, the clover, &c. have a vane belonging to the flower, which the wind turns in such a manner, as always to keep the more delicate parts from facing the blast, like the contrivance we often see on the tops of chimnies, to prevent the wind from blowing upon the passage where the smoke is discharged. The flowers of some plants, as the dandelion and many others, always *shut up* at night; others, like the English sunflower, have the singular property of *turning round*, so as to follow the sun, and afford the seed and fruit parts the constant advantage of his rays.

T. Is there any thing in the cup or leaf part of the flower which evinces design?

A. It affords the advantage of a wall or a shelter around the delicate fruit parts within. Its *shape* is generally well adapted to reflect the rays of the sun toward the middle, where these parts are situated; and the *high polish* on the inside, must contribute to the same effect. It is observable, that it decays and falls off, and is the only part of the plant that does, as

soon as the styles and stamens have performed their office, and the delicate embryo of the fruit has made a little progress in its growth.

T. Is there any thing to oblige the pollen or dust, which is necessary for the formation of the fruit, to light upon the pointal where its office is to be performed?

A. The provision for this purpose is remarkable. In the first place, the *pointal* is generally in the *middle*, the most favorable situation for receiving the dust from the stamens which stand *around* it. Secondly, it is usually shorter than the *stamens*, so that the pollen more readily falls upon it. Sometimes the head of the flower hangs down, as in the Crown Imperial. In this flower, therefore, the pointal ought to be the longest, for the dust to catch upon it in its descent from the stamens. We find upon examination, the usual relative length of the pointal is here *actually* inverted, and is greater than that of the stamens. It is generally the same in all the drooping flowers.

In some flowers the stamens lean over, one or two at a time, on the pointal, retiring after they have shed their dust and giving place to others. This is very striking in the *Garden Rue*. The five stamens of the *Cockscomb, (Celosia)* are connected at their lower part by a membranous web which in moist weather is relaxed, and the stamens spread for shelter under the leaves of the flower; but, when the air is dry, the contraction of the membrane brings them together, to scatter their pollen in the centre of the

flower. There is a similar fact with respect to the beautiful shrub which many call the *sheep kill or lamb kill;* botanists, the *kalmia.* The ends of the stamens are bent back and protected in little depressions upon the inside of the cup of the flower, until, at the proper time, they suddenly liberate themselves from their confinement, and dash the pollen with great force upon the pointal. In the *barberry bush, (Berberis),* the stamens shelter themselves under the leaves of the flowers, whose tips bend over a little to receive them, till *some little insect* in search of honey, happens to touch them at the bottom, when they dart forward, like a *sprung trap,* and discharge their dust upon the pointal in the same way,—and this operation may be repeated in the same flower. Different species of flowers float entirely under water, often at some considerable depth, when they rise near the surface, and throw up their flower spikes above it, and sinking afterwards to ripen and sow their seeds at the bottom.

There are some plants in which the pollen could not easily perform its office, if it were not for a special provision. In the *Indian corn* the pointals, (or *silk,*) are quite remote from the stamens (or the branches of the *spindles*) ; and not only so, the broad leaves of the plant would be likely to intercept the dust and prevent it from falling in the right place: in some trees and vegetables the pointals are upon *one,* and the stamens upon *another,* as in the pine, nut, mulberry, &c. There is a provision against

this difficulty; and it forms one of the most curious facts in botany. The pollen is *light* and *floats off* easily into the air so as to escape obstructions or pass from plant to plant. It is done in this manner. Every particle of the pollen contains a very minute quantity of what the chemist terms *hydrogen gas*, which is much lighter than air, and which, for that reason, is used in inflating *balloons*. Now to steer these little particles to their destined places there is said to be an *attraction* between the dust and the part for which it is designed; and that as soon as it lodges upon this part, the balloon bursts, the hydrogen escapes, and the dust remains fixed upon the pointal where there is *a gummy substance to hold it fast.*

B. Another beautiful instance in which our most ingenious arts have a more perfect *precedent and pattern* in the works of Creation! Here, it seems, we not only have the balloon, but what our *aeronauts* have yet to discover, how to *direct* its course.

A. In the seeds of plants, we have to notice the great principle we see in all the works of nature, that every thing is provided for with an attention proportionate to its importance. If the *seed* should fail, the plant cannot be reproduced. We may here therefore admire, that *this* part of every vegetable discovers the most care for its perfection and preservation. We find it in shells, stones, husks, pods; always cased and defended by something hard, so that however rudely we may handle it, the miniature

plant within remains unhurt. As if endowed with a knowledge of the tender embryo it contains, the seed will never expose it by opening in any situation where the little root would want warmth and moisture to nourish it.

We have this exemplified in the backwardness of seeds in a dry, cold spring. The seed, as we may say, is here often *wiser* than the planter; who regrets the tardiness of the germination, without reflecting that any precipitancy in this particular would be fatal to the plant. It is an admirable constitution of seeds which we can only refer to design, that they are invariably slow in opening when the safety of the plant requires they should not begin to shoot shortly after they naturally fall; as is the case with nuts and many others, which are dropped too late for the plant to become sufficiently hardy to endure the cold of winter.

From one part of the seed, the sprout comes forth which is to form the stem; and from another the sprouts which are to become the roots. This provision is a curiosity of vegetable instinct; though some have thought the attraction of the earth, or gravitation has much to do with it. But it is to be admired, however accounted for. For deposit the seed in the ground in any manner we may, the stem comes up, the root goes down. This buisness is not left to our care; that is to say, what we could not easily do if we would, plant every seed in a particular position, is rendered unnecessary by the wise provision of the Creator.

The same providence attends the plant in the different stages of its growth. The provisions for supporting the plant, and giving it the benefit of sun and rain are a manifest display of purpose and wisdom. The stems are made strong and erect for this purpose, with one large class of exceptions, such as the *honey-suckle*, *grape vine*, &c. These are furnished with a substitute viz. the *tendrils*, by which they are enabled to climb up. One might be challenged to imagine a clearer instance of design than this; thus there is not one tree or shrub or herb which is able to stand alone, that is furnished with a tendril. "We may make only so simple a comparison as that between a pea and a bean. Why does the pea put forth tendrils, the bean not; but because the stalk of the pea cannot support itself without them, the stalk of the bean can; we may add also a circumstance not to be overlooked, that, in the pea tribe these clasps to do not make their appearance till they are wanted; till the plant has grown to a height to stand in need of support."

Plants are generally more or less improved from their natural state, by cultivation. Some acquire new fragrance and beauty. In others, the fruit is rendered more wholesome, delicious and abundant. The *rose*, by being transplanted from its native fields, has been changed from a single flower into one of the most magnificent ornaments of our gardens. The apple, pear, &c. on the contrary, have been improved principally in the fruit. In this singular difference in the effects of cultivation in different plants,

for which there is no natural reason we know of, we can plainly see the *goodness of Providence.* The case is this: the improvement produced by cultivation in the beauty of flowers, chiefly consists in increasing the number of the flower leaves, botanists term them the *petals*, which in those flowers, called *double* flowers occupy the cup designed for the fruit bearing parts, that is, the pointal and stamens, so that the improved beauty is not obtained but at the expense of the fruit and the seed. The design intended to be noticed is this; that when it is the *flower* which is changed, we shall find the general distinction is, that it takes place in those plants whose principal value to us is their *beauty;* while *fruit trees* preserve the simplicity of the flower; and the improvement is confined to the fruit under every degree of culture. It would be a small compensation for the barrenness of our orchards, that *the flowers were double in the spring.* Why in the rose bush, cultivation doubles the flower, and the apple, (the red bud), is not improved; and in the orchard trees, it improves the apple, and leaves the flower single, can only be attributed to that beneficent design, which in every thing has consulted the greatest degree of utility. The original potatoe was introduced into Europe from the mountains of Peru, and has become infinitely more valuable, as an article of food, by cultivation. Here the *root* is improved; but the flower remains as simple as in the state of nature. A more *beautiful* potatoe field would poorly reward us for the

loss of one the most valuable vegetables. The same is true of the esculent roots, the carrot, parsnip, and many others.

B. How striking an evidence of benevolent design! Every plant is made to improve for the benefit of the cultivator; and laws apparently the most arbitrary are established, by which the *kind* of improvement is such as would be most for our advantage.

T. What are the *properties* of plants in which we discover a wise and benevolent Providence?

A. Besides nutritive, medicinal, and ornamental plants, which contribute to our benefit and enjoyment in innumerable ways, *all* plants exert a salubrious influence on the air. The air is found to undergo a chemical change by every breath we inhale, every fire we kindle, which unfits it for respiration. It loses a certain principle necessary to support animal life. At the same time its purity is impaired by the continual decay of animal and vegetable substances.—Amid all these causes which operate to diminish the purity of the air, nature has provided the *plant* as a restorative. It *restores* the salubrious quality which has been removed; it *removes* the pestilential quality which has been imparted.

B. One would suppose that all these *bad* properties could not be removed by the plant, without its suffering for the friendly office which it performs.

A. The plant derives *nourishment* from the air which has been contaminated by the animal; while it

exhales in return the vital principle which the animal wants.

T. Such *used* to be the theory. But late experiments have given rise to some different views upon this subject.

A. Agitation with water is one of the restoring causes which the wisdom of the Creator has provided to purify the air. "The foulest air shaken in a bottle with water for a sufficient length of time, recovers a great degree of its purity. Here we see the salutary effects of *storm and tempests.* The yesty waves, which confound the heaven and the sea, are doing the very thing which is done in the bottle. Nothing can be of greater importance to the living creation, than the salubrity of the atmosphere. It ought to reconcile us therefore to these agitations of the elements, of which we are apt to deplore the consequences, to know, that they tend powerfully to restore to the air that purity which many causes are continually impairing.

B. Hence I suppose that delightful sweetness and freshness of the air after a shower.

T. What are some other of the principal marks of design we discover in the elements?

A. Without *air,* neither vegetable nor animal life could be supported. Water could not be carried up from the earth, nor supported in the form of clouds, nor when descending, could be distributed in dew and rain drops. Without the air to reflect the rays of light, the instant we *turned our back upon the sun,* we should be immersed in total darkness.

In *water*, it demands our gratitude, that the most necessary liquid is the most abundant and most easily obtained, and has no taste of its own either to offend, or satiate; or to effect the flavor of any thing united with it. One of most remarkable circumstances in which we discover *design* in the properties of water, is the manner in which it is affected by *frost*. It is a provision in the constitution of this most useful element, to preserve it from the sudden effects of hard frosts; that is, in those places where it is of the greatest importance to us, viz. the deeper waters, such as wells, rivers, bays, &c. A short account of the matter may be this. Water will not freeze, till it is cooled down to *thirty-two* degrees of the common thermometer. But water is *heavist* when at the temperature of about *forty* degrees. The consequence is plain. When the surface of the water is cooled by a cold wind or a sharp air, to the temperature of forty degrees, it does not wait to be cooled down to the freezing point, which is eight deegrees lower, and to which it would soon be brought if it remained above, exposed to the cold; but being the heaviest, it immediately *sinks*, and suffers a warmer portion below to take its place *This*, also, when reduced to the same temperature of 40, *repeats the process*; and thus the *whole* quantity must come to the surface and be brought to this particular degree of cold, which is eight degrees above the freezing point, before the circulation will stop. After the whole mass has thus been brought to the heaviest weight which water can acquire, then the surface

will remain *stationary*, and the cold wind or air will soon reduce it to the state of *ice*. The time necessary for this circulation to be completed, must depend on the depth of the water; and in deep pieces of water, it is sufficiently long to ensure them from being frozen over, unless the cold should be continued for a considerable period.

To this provision we are indebted for the use of our wells, fountains, and navigable waters in cold weather. They would otherwise be closed up with the first frosty night. The whole fact is one of modern discovery, Dr. Johnson was led to doubt that a small but very deep lake in the highlands of Scotland, was always open in the hardest winters, while other lakes in the neighborhood were frozen over. If the fact were true, he thought the phenomenon must be owing to the water being unusually sheltered.

"For where a wide surface," he observes, "is exposed to the full influence of a freezing atmosphere, I know not why the depth should keep it open." The difficulty to his mind of conceiving how *depth* should protect the *surface*, may still further impress us with the wisdom of the arrangement by which the effect is produced.

Without *fire*, all substances would be converted into one solid mass; fire being the principle of fluidity in water and every other liquid in nature. The very *air* itself would become solid. Fire is the universal instrument of all the arts and all the necessaries of life; and here we are called to admire, that fire and light, in the absence of the sun, are obtain-

able, and so easily, from a variety of sources, such as wood, oil, and all combustible bodies :—and what is more observable, since we could not have conceived of its possibilty, this *diffusive* and *destructive* element of fire is so quietly and safely *concealed* in all these substances, till we have occasion to make use of it.

ASTRONOMY.

T. It becomes most interesting to inquire whether we are able to pursue the *same system of design* into the remoter parts of the universe which fall within our observation.

A. We are not indeed able to pursue our researches into the heavenly bodies, as into the structure of a plant or animal ; but the knowledge we have is sufficient to convince us they are a continuation of the same skilful and beneficent contrivance we find to be so perfect in the objects we are able to examine ; that is, to examine so *nearly* as to trace the minute relations and correspondency of parts.

T. You may mention some of the most conspicuous marks of design and wisdom in the *Solar System.*

A. In the first place, it is a plain manifestation of design and of a designing Creator, that the *Sun* is situated in the *centre ;* and that the earth and planets are disposed *around* the orb by which they are warm-

ed and enlightened; that is to say, that the bodies which require the benefit of his illumination and heat, are placed in the most favorable position for receiving them. We know of no *natural* cause why the *central* body must be luminous. We see the *wisdom* of the arrangement; but here our knowledge ends.

T. But there is more to excite an admiration of the wisdom exhibited in this stupendous part of the fabric of the universe.

A. In the revolution of the earth and planets around the sun we behold an example of mechanism on a scale exceeding our imagination; but still, wherein we perceive manifest contrivance; as much as in the motion of a watch or the turning of a joint.— The planets revolve by means of *two* forces. The one is the *force of attraction* which the sun exerts upon them, like that of steel upon a magnet. It is termed the force of *gravitation:* and if they were to comply with *this* force only, they would rush to the sun and be consumed. The *other* force is one which continually impels them to move off from the sun, like a ball from a sling; and if they had obeyed *this* force alone, they would long since have withdrawn from their orbits into the depths of infinite space.— The whole is perfectly illustrated by the whirling round of a ball fastened to the end of a string. The ball is drawn to the hand by the string; this is *one* force; the motion of the ball impels it to recede from the hand, so that if the string should separate, the ball would fly away. This is the *other* force. Both acting together, compel the ball to revolve round the

hand. In the planetary revolutions there are the same two forces; the only difference being, that the attraction of the sun upon the planets *is a substitute for the string.*

B. From how simple powers are the most stupendous effects produced in nature! What an amazing conception, that the simplest toy of a child comprehends the whole mechanism of worlds all in rapid motion, yet calm, regular and harmonious.

T. But this admirable mechanism is not to be understood from so simple an illustration as this, except in some very general points of view. There are important respects in which it fails to convey any adequate idea of the wisdom exhibited in the planetary frame. The earth and planets are held in their orbits by the attraction of the Sun. This is true. But the attraction is not peculiar to the *Sun.* It is an attraction which *all* bodies exert upon one another in proportion to their quantities of matter. The sun being by far the largest body in the system, possesses the most of this attractive power, on account of his superior magnitude. And *all the planets* exert the same kind of attraction upon one another, though in a less degree. If we were to fasten a number of loadstones to separate strings, and whirl them around another larger loadstone in our hand, this would resemble the sun and planets;—but then while the loadstones revolved they would be liable, from their natural attraction, to *rush together* and form one solid mass. What is to prevent the planets from doing the same, and involving the whole system in destruction?

A. We have here new occasion to acknowledge the Creator's wisdom in preserving the harmony of the system by one of the most wonderful laws which he has impressed upon matter. It is this. While the earth and all planets are continually exerting an amazing force of attraction upon one another, like so many loadstones, yet the mathematician can demonstrate they shall never rush together, nor materially disturb their respective revolutions, provided a few conditions exist. One condition necessary is, that the attraction be *weaker* the farther they are apart; and not only so,—but exactly *four times* weaker, when the distance is *doubled.* Upon this condition and a few others, but this is the principal, he is able to demonstrate, without observing the heavens, without seeing how the fact in reality is, *there,*—that no danger exists from the mutual attraction of the heavenly bodies; draw upon one another as long and as powerfully as they are able; change their relative positions as they can; now retreating, now advancing; here the matter must end; they can never *touch*, they can never permanently disturb each other's separate and orderly revolutions. Now, wonderful as it must seem, all these conditions exist in the solar system; and among others the main and most important one, to wit, the force of planetary attraction is exactly *four* times weaker at *twice* the distance.

Why not three times, or five times, or in any other proportion? Of the infinite number of *possible* proportions, had it been any other than the one actually

adopted, it has been demonstrated, so far as the investigation has been carried, that the consequences would have been fatal. But still, what has established this particular law of the attractive power? As an eminent mathematician observed, we know of no reason, but that it *was* so established.

T. It is sufficient for our present views to notice a few only of the connected instances of design we perceive in nature, and which stamp one united impress of the Supreme Creator upon every object; to see every thing concurring in the same demonstration of his Almighty agency; and announcing the Eternal Power of whose perfections we have been privileged with such glorious manifestations. I shall not pursue the consideration of all the particular attributes of the Deity which are evidenced; such as his Unity, Eternity, Immensity, Omnipotence, and Infinite Wisdom; but will now ask what is the grand conclusion we obtain from a collected view of those innumerable traces of design we discover in the works of God. To what end does design appear to be directed?

A. A good and benevolent end. In countless instances we are enabled immediately to perceive this end; and the presumption is overwhelming, that it is universal, and that *all creation* is a display of the infinite goodness of its gracious and adorable Author.

Whatever we observe in nature, which lies within a compass so suited to our knowledge, that is, so limited a compass, that we can feel satisfied that we *understand* it; that we see the end to be obtained, and the means suitable to be employed; in *every such* in-

stance, we discover a useful and beneficent arrangement *actually* adopted, and *no other*. In examining the human frame; the mechanism of the bones and muscles; the organs for nourishing the system; the admirable covering by which it is shielded, and preserved in an agreeable and healthy temperature;—here is a case within our comprehension. We see the *objects* to be effected; and we understand in a good degree, the *means* which are necessary to effect them. We see that a locomotive animal, an animal that must move in order to subsist, requires limbs of particular dimensions and forms;—and muscles adapted to set these limbs in motion; and alimentary apparatus to support these muscles in life and vigor. It is a case within our comprehension: only a few plain principles of contrivance happen *here* to be involved, similar, for the most part, to those we are familiar with in mechanism of our own; and *here* we discover the most consummate evidence of design usefully and benevolently directed. We are acquainted with the *mechanical* powers. We understand the nature of a *pulley*. We *know* what is to be done, if it is proper the eye should be drawn upward or downward, or in this direction or in that, for the purposes of vision. We find it *is* done. If the human body is to be nourished by food, which food must be divided and ground to fit it for the digestive organs; here is a case within our certain comprehension, in the end and in the means; and we can unhesitatingly pronounce, that *teeth* are a necessary provision. We *find* them provided; and in every animal perfectly adapted to

the nature of the animal's food. Here is a *fitness* of which we are competent to judge, because it happens to be too simple,—involves too few principles, for us to mistake.

When the *nature* of the case brings it *fully* within our knowledge, the arrangements we discover are invariably perfect. And when we consider how numerous, how countless are the instances of this description, through all the multitude of living and organized beings; through all the complexity of their structure; through all the adaptations of their powers, physical and instinctive, to their subsistence and comfort; through so many cases of wise and benevolent arrangement in the vast compass of nature; we cannot reflect without the profoundest admiration, that in proportion as our knowledge of any thing in creation approaches to certainty, our perceptions of Divine wisdom and benevolence are satisfactory and unclouded. What an argument for suffering no limitation of our trust and adoration towards that *High and Holy One, of whom, and through whom, and to whom are all things!* What a reason for bowing with devout and cheerful acquiescence to the precept of our Saviour, who suggested the same idea in commanding his disciples, as to all future events, and all things occasioning their solicitude, to confide in that Being who had so perfectly exhibited his goodness in cases within their certain knowledge and actual observation! *Behold the fowls of the air: for they sow not, neither do they reap, nor gather into barns; yet your*

heavenly Father feedeth them. Are ye not much better than they.

To say, that in all the innumerable contrivances of nature there are *prevalent* marks of a merciful and benevolent author, is to pronounce that *all* his intentions are gracious; as what is *prevalent* in his acts, must determine the *nature* of his intentions, and be regarded as the decisive indication of his moral character. The general impress, therefore, of beneficent design, so legibly stamped upon the operations of Providence, is of itself sufficient to demonstrate, that the goodness of Omnipotence is every where exhibited, and that all its designs are good. "Nor, (as it has been truly said by a most devout and delightful writer), is the design abortive. The air, the earth, the water, teem with delighted existence. In a spring morn, or a summer evening, on whichever side I turn my eye, myriads of happy beings crowd upon my view. The insect youth are on the wing. Swarms of new born flies are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy, and the exultation they feel in their lately discovered faculties. At this moment, in every given moment of time, how many myriads of animals are eating their food, gratifying their appetites, ruminating in their holes, accomplishing their wishes, pursuing their pleasures, taking their pastimes. In each individual, how many things must go right, for it to be at ease; yet how large a proportion out

of every species is so in every assignable instant. In our own species, the preponderance of good over evil, of health, for example, and ease, over pain and distress, is evinced by the very notice which calamities excite. What inquiries does the sickness of our friends produce? What conversation their misfortunes? This shows that the common course of things is in favor of happiness; that happiness is the rule—misery the exception. Were the order reversed, our attention would be called to examples of health and competency, instead of disease and want. One great cause of our insensibility to the goodness of the Creator is the very extensiveness of his bounty."

T. Do we discover any arrangement of Providence that seems intended for the production of mere pain or unhappiness?

A. No one, it is believed, will profess to be acquainted with such an instance. Evil, as such, never appears an end in any thing in nature, with which we are acquainted. In describing a particular tool you would hardly say, this is made to cut the mechanic's hand; though from inattention in the use of it, this mischief may often occur. "But if one had occasion to describe instruments of torture, he would say, this engine is to extend the sinews; this to dislocate the joints; this to break the bones; this to scorch the soles of the feet. Here pain and misery are the very objects of contrivance. Now, nothing of this sort is ever to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a train of organi-

zation calculated to produce pain and disease; or in explaining the parts of the human body, ever said, this is to irritate; this to inflame; this gland is to secrete the humor which forms the gout." If he is ignorant of a useful purpose, he considers his knowledge as yet imperfect; and pursues his inquiries with the fullest confidence that there is yet a discovery to be made.

T. If there are so many demonstrations of beneficent design in the works of Divine Providence, which we are able to perceive and understand; and there is no instance where a want of design can be proved; and none in which evil, as such, appears to be the object of design;—what is the proper view to be taken of any of the seeming ills of life which God has appointed to us?

A. Revelation declares they are intended for a wise and beneficial purpose; and any other conclusion would be infinitely unreasonable. It would be infinitely unreasonable to suppose that any thing in Providence should want a useful design even though it be pain and affliction, when we see the evidence there is of a wise and benevolent Being *whose tender mercies are over all his works.*

T. But what say you to such evils as the *vices and sins* of which men are guilty?

A. These are not the evils of *Providence;* but they are those which men bring upon *themselves* by their own misconduct, thwarting the designs of their being, and the kind purposes of their nature.

T. Wherein do you perceive in moral evils any *thwarting* of a natural design?

A. God has made inconvenience and suffering, of some description or other, the *regular* and *natural* consequence of all criminal and excessive indulgences of our passions; and *this* proves a natural design has been violated,—as much, as the pain which arises from bending a limb contrary to the natural direction of the joint, evinces that the limb was not *intended* to be bent in that manner. Besides, our Creator has placed reason and conscience in our breasts, which always oppose the commission of conscious vice and misconduct:—and we *feel* that they are by *right* the presiding governers of our behavior. We are as *naturally* sensible of it as of any truth whatever.

T. But Providence has subjected the *best* to suffer in this world; and oftentimes it is their virtuous feelings which occasion their troubles; as when they suffer under the reproaches and ill treatment of bad men; or from the strength of their virtuous attachments to other sufferers. They are subjected also to death; and, what it is impossible to overlook or conceal, the more they cultivate their minds, and follow the impulse of those noble capacities with which God has endowed them, the more unhappy do they feel it, to be denied the opportunity of continued advancement in improvement and usefulness; the more they know of their *Creator*, the more they adore and love him, the more terrible to think of being *separated* from him forever. What design can you dis-

cover here?—What design in such a constitution as this; that the *better use* we make of our minds, the more does this life appear too short and inadequate to our feelings?

A. The system of Providence would lead us to conclude from what we generally see, that capacities are not given in vain. They are not made *systematically* and as a *settled* course to stop before they have finished their work, and reached their highest consummation. Generally, the animal being does not perish till its powers are perfectly developed; nor the tree till it has reached its height. If therefore man has capacities of higher improvement than the present world unfolds, the presumption on natural principles is, that this life is to be succeeded by another. We see the best of the creatures of God, universally stopped in their career; stopped by infirmity and death; stopped in their *progress;* stopped at the period of their most *pleasing and rapid* progress. Not so with the brute. His powers have no progress that we know of. He has reached the end of his faculties, to all appearance, long before he dies. The plant has reached the termination of its vegetative powers of bloom and of fruit bearing, before it decays. But *man* is stopped. The tree falls in mid vigor. The sun goes down at noon.

T. But is there any natural *example* to correspond to the delightful and glorious anticipation of a renewed period of existence for those capacities of improvement, which in this life are arrested in their progress?

A. The examples are often before us.—The *seed* has capacities of further advancement, that is, of shooting up into a tree, when it apparently dies in the earth ; and the consequence is, the death is only *apparent.* The tree actually succeeds. The *worm* has capacities of further advancement, of advancing from the earth to the air ; and the consequence is, it *leaves* its shroud, and soars upwards from a state of seeming insensibility, to enjoy the more beautiful existence of a butterfly. Prior to *experience,* neither of these events would have been anticipated. We see a butterfly in a maggot no more distinctly than we see an immortal spirit in mortal man.

T. But in so important a case might we not have expected some further evidence ?

A. That evidence we enjoy in the *Revelation by Jesus Christ,* who has brought life and immortality to light.

T. And what has Christ Jesus taught us respecting a future life ?

A. That it shall be a state of recompense according to our characters. He has told us that the present life is a state intended to prepare us by the knowledge of God we here acquire, the holy dispositions here formed in our souls, and the practice of piety and virtue, for a state of heavenly felicity ; and that if we love wickedness, neglect our minds, and hearts, and abuse the talents which God has given us, —the consequence will be misery hereafter.

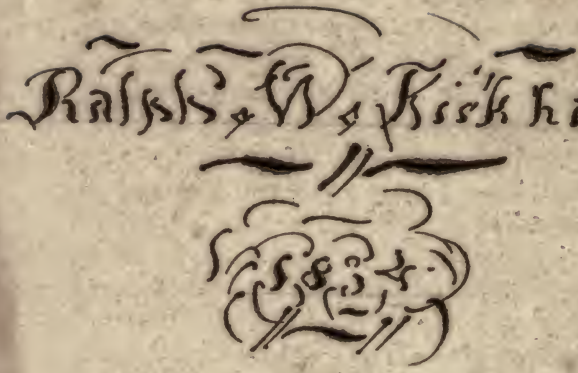
T. Do you see any thing in the present course of Divine Providence in this life, to correspond to this

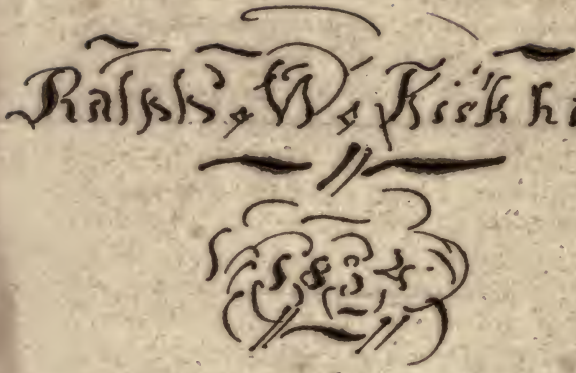
representation which Jesus Christ has given us of a state of recompense ?

A. Yes. In the general providence of God childhood has very much the same relation to mature age, as this world has to the world to come. If we fail to govern our passions when we are young, they usually govern us, and render us miserable in the after stages of life. If we *then* form virtuous and religious habits, cultivate our minds, and improve our opportunities aright, we are *sure* to rewarded in the effect produced upon our characters, feelings, and happiness in the future periods of our days. The good and the evil are placed before the *child;* and as his choice and conduct shall be, so, in the general course of divine providence, are manhood and old age remunerated.—Not so, with any other being but man. It is not left with the chicken to choose whether or not it will follow its instincts, so as to become *a happy bird*, when it has grown up. In our *present* existence, therefore, there is a distinction from that of inferior animals, similar to what revelation teaches us to expect with reference to a *future* state.

T. And now, what ought to be your endeavor and your prayer ?

A. What I desire to ask is that mine may ever be, "*by patient continuance in well doing to seek for glory, honor and immortality.*"





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